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THE

BUILDER'S

COMPLETE GUIDE:

COMPREHENDING

THE THEORY AND PRACTICE

OF

THE VARIOUS BRANCHES OF

Architecture,

BRICKLAYING, MASONRY, CARPENTRY,

JOINERY, PAINTING, PLUMBING,

&c. &c.

BY C. F. PARTINGTON,

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ILLUSTRATED BY ENGRAVINGS.

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The following Pages form part of a larger Work, now in course of publication, expressly adapted to the use of operative Artists, and Manufacturers, entitled The Mechanics' Gallery of Science and Art; to which circumstance it is owing that these pages begin with folio 289. The general utility of the subject matter has induced the Proprietors to print an extra number of Copies of this portion of the Work, in order to the accommodation of the public at large, as well as of those more immediately connected with the different branches of Building.

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THE

BUILDER'S

COMPLETE GUIDE.

ARCHITECTURE.

Of the paramount importance of architecture little need be said; whether we consider it as a mechanical science, sheltering under its ample wing the several employments of masons, carpenters, smiths, and all those artizans whom modern refinement has rendered necessary for the enjoyment of life; or as a fine art, exercising the highest powers of the human mind, and becoming the parent and preserver of painting and sculpture, whose very existence almost depends upon it. But to commence by lavishing encomiums on this noble art, would be to presume on the patience of the reader before he is satisfied that our conclusions are just: we will therefore proceed, first, to give a brief sketch of its history and progress; next, detail the characteristics of each principal style that has prevailed in the world from the earliest recorded period; and lastly, descend to the humbler yet more useful department of the arrangement and construction of dwelling houses, and building in general, the particular parts of which, such as carpentry, masonry, &c. will be more fully described under their respective heads.

At a very early period, as might be expected, architecture had made some progress; for we are informed by Holy Writ, that Cain "builded a CITY, and called the name of the city after the name of his son, Enoch;"* but we are wholly in the dark as to the perfection to which it had attained when that awful visitation of the Almighty, the universal deluge, obliterated almost every mark of previous habitation. The next mention of it is in the account of the building of

* Genesis, chap. iv. v. 17.

the tower of Babel, which was stopped by the confusion of tongues. This was soon surrounded by other buildings, and walls of great magnitude, and here, therefore, may we date the origin of post-diluvian architecture. Whatever celebrity however the wonders of Babylon attained among the ancients, no remains of them have come down to us, and it is the massive edifices of Egypt, built apparently rather for eternity than time, that now excite our admiration as the most ancient as well as stupendous structures existing upon earth. We must not, while under this epocha, omit to notice the remains, and alas! the only remains, of Indian and Mexican greatness. But for the splendid ruins at Delhi and Agra, and that most singular specimen in the island of Elephanta, we should scarcely have known of the existence of civilization among the ancient Hindoos; and the aborigines of Mexico were regarded as little better than savages, before the late discoveries by Mr. Bullock. The dates of these buildings are wholly unknown; but from the general similarity they bear to those of Egypt, it is supposed they are of at least equal antiquity. It may not be improper here to observe, that the latter country is commonly considered to have been peopled by a colony from India. About the same general date may also be classed the architecture of the Hebrews, or, as more properly characterised, the Phœnician style, the greatest monument of which was the far-famed temple of Solomon. The description of this in the sacred text, will be found, on an accurate consideration, to bear great resemblance to that of many of the Egyptian temples.

From the Egyptians, the art, such as it was, was learned by the Greeks; but under the protection of that extraordinary people it reached a perfection unheard of before, and, in its peculiar style, unequalled since. The earliest edifices of Greece, however, were by no means remarkable for beauty, the temples in the time of Homer, being little better than rude huts, sheltered, if sheltered at all, by branches of laurel and other trees. On the decline of Greece, and its conquest by the Romans, the art appears to have been transferred to the conquerors, but among that hardy and warlike race, it made little progress before the age of Augustus. Under the protection of that munificent monarch it rapidly attained to almost as great perfection as in the favoured country of the arts, and the "eternal city" owes much of its present estimation to the noble structures erected by him and his successors. With Rome, however, the art decayed, and was overwhelmed in the general confusion and oblivion of learning, art, and science.

The attention of the Saxons in our own country, probably about the eighth century, was excited by the remains of edifices raised by the Romans during their residence in England. These, in their newly erected churches, they aspired to imitate, but their workmen, ignorant of the principles which guided the architects of those splendid ruins, produced only the general outlines of their patterns, and those clumsy forms continued to be practised with little alteration till the end of the twelfth century. But now, as the tumult excited by the invasion subsided, and the genius of the nation improved, a taste for the fine arts began to show itself, and architecture assumed a different and novel aspect. Instead of tamely treading in the steps of their predecessors, the architects of those times devised a style as scientific as it was grand, and as beautiful as new.

But we must not, while eulogizing those who have adorned our own country with such admirable structures, forget the merits of their contemporaries on the continent: of these it seems to be generally acknowledged, that the French preceded us in point of time, and the Germans excelled us in the size of their edifices: yet no one, on comparing with an impartial eye the several buildings, will hesitate to allow, that in purity of style, variety of design, and delicacy of execution, the English cathedral, and other churches, are not surpassed by those of any nation in Europe; and it is a remarkable fact, that English architects and workmen were employed in many of the finest works on the continent.

We must now turn our attention to Italy: it is worthy of notice, that the Gothic style never came to so great perfection in this country as in the neighbouring nations. Perhaps this was owing to the number of Roman buildings remaining amongst them, and the liberal use they made of their fragments, which is shewn even in the finest specimen they possess, Milan cathedral. It is not therefore surprising that the Italians should be the first to reject the style altogether. Indeed, there were instances, in the darkest times, of recurrence to the purer models of antiquity,* but these met not the public taste, and were born only to die. "It is not," observes Mr. Bromley, "the casual and solitary effort of individuals in a dark age which can be considered as renovating the decayed principles of pure science. Some minds are naturally stronger and more intent on improvement than others, and where such happen in some degree to break through the general obscurity, they only shew that the genuine light of refine-

* It should be remembered that we here speak of *Italian* Gothic.

ment is not quite extinct, though the age will be little or nothing the better for those fainter glimpses, which become the portion of one or two, and are neither attained nor sought by others."

To return to our subject. The church of the Apostles at Florence, which was built by Charlemagne in A. D. 805, appears to have been the first effort to revive the forgotten architecture of ancient times, and possessed so much merit, that Bruneleschi, 600 years afterwards, disdained not to accept it as a lesson in one of his own edifices. Two hundred years passed away, and the church of St. Miniate, in the same illustrious city, momentarily recalled from its apparent oblivion this elegant style. The same period again elapsed, and the genius of Cimabue arose to dispel the mists which had so long enveloped the arts of his country. His attention, though principally devoted to painting, was like that of most of the great artists of his time, occasionally turned to the sister arts, and it was partly by his instruction that Arnolpho Lapo became the wonder of the age. The father of this eminent architect, James, was a German by birth, but resided at Florence, where he built the convent of St. Francis, and received the surname of Lapo from the citizens for his skill in architecture. The son, Arnolpho, built the cathedral of St. Marie del Fiore, the largest church in Christendom next to St. Peter's. Although this was principally in the Tedeschi style (the appellation given by the Italians to the debased Gothic of their country), yet so uncommon was the skill displayed in its erection, that the dome being left unfinished by the death of the architect, a century and a half elapsed before another could be found to raise it. This was Bruneleschi, who died in the year 1444, and may be considered as the reviver of the classical architecture. His principal work was the Palace Pitti in his native city.

It might have been expected that Rome, which possessed so many fine specimens, would have been the first to shew to the world her sense of their value by encouraging their imitation; but it was not till the middle of the fifteenth century that Pope Nicholas the Fifth shewed the first symptoms of reviving taste by the encouragement of Leon Baptista Alberti (the earliest modern writer on architecture) and Bernardo Rossilini. These, however, were principally employed in repairs, and the erection of fountains, and to Bramante must we concede the honour of being the first who materially adorned this city by his designs. With the then Pope, the memorable Julius the Second, he was much in favour, and it is supposed that it is in a considerable degree owing to this architect that that magnificent pontiff formed the resolution of

rebuilding the cathedral of St. Peter in a style suited to the importance and magnificence of the see. In the life-time of Bramante, however, little was done of this stupendous work; for such was the conception of the architect's colossal imagination, that, although in its present state its section is about double that of St. Paul's at London, it was reduced by his successor, Balthazar Peruzzi; and more considerably by the next who took it in hand, Antonio di San Gallo. These architects, however, while they exerted their talents on paper, proceeded little with the work, and it was left for the sublime genius of Michael Angelo permanently to fix the design of this master-piece of art, and prince of Christian churches. The edifice, as we now see it, is principally his, except the front, which is considered inferior to the other parts. This work completed, the example thus set by its principal cities was quickly followed in all parts of Italy, which thus gave employment to the talents of Pirro Ligorio, Vignola, Dominico Fontana, Michael San Michael, Falconetti, Sansovino, Serlio, Barbaro, Scamozzi, and Palladio.

The pure taste which characterised most of these architects, however, was not of long duration. The celebrated artist, Bernini, was one of the first who violated their precepts. He was educated at Rome as an architect and sculptor, and it is related of him, that returning to his native city late in life, with a large fortune, the product of his talents, he was much struck with some of his early works of the school of Michael Angelo and Palladio. He could not but contrast their elegance with the affected graces of the style he had given into, "but," exclaimed he, "had I continued in this manner I should not have been what I am now." Contemporary with Bernini was Borromini, who was yet more depraved, and was so jealous of the former's fame, that he stabbed himself. After these, Italy cannot boast of any great architects, and we must now return to our native country, as more interesting to its inhabitants, and indeed of more importance in our history than France,* or the other nations of Europe.

From the time of Edward the Third, there was a visible decline in the style of English architecture, which lost itself in a profusion of ornaments, more attention being paid to the details, than to the general forms of the buildings. By the time of Henry the Eighth this increased to

* We have the advantage over our neighbours in the circumstance of one of their principal buildings having been designed by a foreigner (the Louvre by Bernini), while all our buildings of importance are executed by our own countrymen.

a great extent, and the chapel erected by his father at Westminster was one of the last buildings which shewed any taste in the style. This depraved manner naturally excited disgust in the minds of those persons who had seen the purer style then prevailing in Italy, which, as might be expected, they endeavoured to introduce. The nation, however, had been too long accustomed to the Gothic readily to surrender it, and during the reigns of Elizabeth and James, the mixture of, or compromise between, these styles produced a most barbarous result. But this could not last long: the prejudices of the people in the course of time gave way, and Italian architecture in all its purity was first executed in this country by Inigo Jones.

The father of modern English architecture was born about 1572, and died in 1652. At the expense either of the Earl of Pembroke or the Earl of Arundel, he travelled into Italy, and from the sight of the elegant buildings in that country, both of ancient and modern erection, he imbibed a taste for architecture which he put in practice with great success on his return to England. His first work in this country was the interior of the church of St. Catherine Cree in London, and his most considerable design, the projected palace of Whitehall, the part of which that is executed, the Banqueting-house, is barely one-fiftieth part of that magnificent idea. After the death of Jones no considerable architect appeared, till the talents of Sir Christopher Wren (before that time devoted to philosophy and general learning) were called to the aid of the languishing art. He was born in the year 1632, and died at the age of 91, in 1723, after being, in his eighty-sixth year, barbarously dismissed from the office of Surveyor General, which he had held with unparalleled ability fifty-one years. When that temporarily disastrous, yet permanently useful event, the fire of London, occurred, this great man was almost solely employed in rebuilding the numerous public edifices destroyed by the conflagration, and chiefly the cathedral of St. Paul; his execution of which arduous task, whatever be the objections raised against parts of it, by the taste of some, and the jealousy of others, remains a lasting monument of his genius in decorative, and unexampled skill in constructive architecture.

Before the death of Wren appeared Sir John Vanbrugh, who was employed by the nation to erect that monument of national gratitude, Blenheim House. Both the architect, and this, his greatest work, were alternately censured and neglected, till Sir Joshua Reynolds vindicated his fame in his lectures to the Royal Academy. Next in

order were Hawksmoor, the pupil of Wren, Lord Burlington, Kent, and Gibbs, of the latter of whom, Mr. Mitford observes, that allowing his talents to be small, how much do we owe to Lord Burlington, that by his precepts such a man was enabled to build one of the finest modern works, St Martin's Church in the Fields. To Lord Burlington, indeed, it is probable we owe more than is generally considered, for besides the patronage he afforded to the artists of his time, and the assistance he gave them from his own genius, it is perhaps owing to his example, that a general feeling of attachment to the arts was conceived by the young men of rank and fortune in England. The Turkish Government, which in its prosperity, ruled with a rod of iron, the once fertile plains of Greece, began now, in its decline, to relax a little of its ancient rigour, and these gentlemen were thus enabled to extend their travels (which before were bounded by the Archipelago) into this important country. Some of them formed at their return, the Dilettanti Society, for the encouragement of these researches into those (to modern times) new regions. These proceedings could not but excite great interest and curiosity in the public mind, which were fully gratified after some years by Mr. Stuart, who, in a long residence at Athens, made accurate drawings of most of the ancient buildings then existing. These were published in three volumes, folio, to which a fourth was afterwards added by Mr. Revely. The effects of these importations may be seen in every street in London.

The revival of the neglected architecture of the middle ages constitutes a new era in our history. Perhaps the first person who dared to recommend, by writing and example, a style so long in disrepute, was the celebrated Horace Walpole, Earl of Orford, who built the well-known villa of Strawberry Hill, to testify his fondness for it. This was succeeded by Lee Priory, by Mr. Wyatt, who quickly outstripped all the professors of his day, both in this style and the Roman. His greatest work in Gothic architecture was Fonthill Abbey, the merits of which building, when we consider that the architect had no model to work from (there not being another house of magnitude in this style in the kingdom) are truly extraordinary: the purest taste reigns throughout the whole of this splendid structure, and the architect has thus bequeathed to succeeding professors a legacy of incalculable value.

Having now brought our sketch down to the present time, we shall proceed to the second part of our design.

With Assyrian architecture, as was before observed, we are acquainted only by vague and uncertain report; we will therefore commence by the description of

THE EGYPTIAN STYLE.

Did we not know it to be the fact, we have yet every reason to believe, that, in the early ages of the world stability was the first consideration. That men by nature are in a state of great inequality, is a truth which no rational person would be inclined to controvert. Some are weak and some strong, and others have great powers of mind: to these, those incapable of defending themselves would naturally apply for protection against their more powerful neighbours, and hence the origin of civilized society;—but it is enough for our present purpose, that from this combination proceeded the subject of our inquiry. Under these hands, as was before observed, massive strength would be more attended to, than form or adornment. But we do not mean to insinuate, that the buildings now to be considered are exactly of this class; mighty and ponderous they are, but (excepting the pyramids, which did not admit of it,) not destitute of decoration, and some may even be said to possess a degree of elegance.

It may probably be expected, that in delineating the peculiarities of the architecture of Egypt, we should begin with the pyramids, as most readily presenting themselves to the generality of readers. Little description, however, will suffice, to give an idea of these stupendous monuments. The largest of them stands not far from the city of Memphis: it is built on a rock: its base is square, and its sides are equilateral triangles, except that there is a platform at top, of about sixteen feet square, which comparatively is so small, that it is said not to be discernible from below. The stones of which it is composed are of a prodigious size, the least of them thirty feet in height. These are disposed perpendicular, so as to present a series of steps on the exterior.*

But though we have thus thought fit to give a brief description of these mysterious and mighty monuments, it is not the pyramids that characterise the Egyptian style of architecture. Its distinguishing

* It would be idle here to enter into the dispute concerning the original purpose of these structures. It is sufficient to observe that they are generally supposed to have been built as sepulchres for their founders.

marks are to be found in the numerous temples dispersed through the country, one of the most perfect of which, that of Tentyris, is represented in the plate (see Plate VII. A), and will give a good idea of the style. The prominent features of the building being there well defined, farther description is unnecessary. As we know of no proportions attended to in the construction of these edifices, and have no means whereby to judge of their respective dates but by their richness or simplicity (qualities which, though they may be some general guide, are not alone sufficient data from which to form a chronological classification of edifices), we can have little more to say under this head, than to refer the reader, who may wish to make himself acquainted with this style, to the work of Denon, where he will find accurate delineations of the principal specimens. We cannot quit the subject without remarking the great variety and beauty of the *capitals*, in the elegant forms of some of which, borrowed from the palm tree and the lotus, is found a far more probable origin for the Corinthian capital of the Greeks and Romans, than in the pleasing, yet fictitious, story of Vitruvius, hereafter to be noticed.

GRECIAN AND ROMAN ARCHITECTURE.

The architecture of the Romans having been almost entirely borrowed from that of their masters in art, though subjects in dominion, the Greeks, we shall, for greater clearness and brevity, consider them together.

The various parts of which both Greek and Roman orders are composed (the distinguishing members, excepted), being nearly the same in all of them, we shall commence by a description of these. And first, the greater members, which all possess in common. On referring to our plate it will be seen, that we have marked letters, answering to dotted lines, proceeding from the order to the left hand. Of these, the upper division, *a*, is the *cornice*, *b*, the *frieze*, and *c*, the *architrave*: these form the horizontal part of the order, and are called the *entablature*. *d*, is the *capital*, *e*, the *shaft*, and *f*, the *base*. These together form the *column*, or upright, supporting-part. The column is usually placed on a square tile, called the *plinth*, *g*. These, according to the variation of their parts, form what are called the *orders* of Greek and Roman architecture, which will be presently the subject of our discussion.

The prototype of this arrangement, is supposed, by Vitruvius, and a

host of followers, to be the timber hut, of which we find the following account in Sir William Chambers. "Having marked out the space to be occupied by the hut, they fixed in the ground several upright trunks of trees to form the sides, filling the intervals between them with branches closely interwoven, and spread over with clay. The sides thus completed, four beams were laid on the upright trunks, which, being well fastened together at the angles of their junction, kept the sides firm, and likewise served to support the covering or roof of the building, composed of smaller trees, placed horizontally, like joists, upon which were laid several beds of reeds, leaves, and earth or clay.

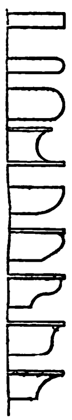
"By degrees other improvements took place; and means were found to make the fabric lasting, neat, and handsome, as well as convenient. The bark and other protuberances were taken from the trees that formed the sides; these trees were raised above the dirt and humidity on stones; were covered at the top with other stones; and firmly bound round at both ends with ozier or cords, to secure them from splitting. The spaces between the joists were closed up with clay or wax, and the ends of them either smoothed, or covered with boards. The different beds of materials that composed the covering were cut straight at the eaves, and distinguished from each other by different projections. The form of the roof too, was altered; for being, on account of its flatness, unfit to throw off the rains, which sometimes fell in great abundance, it was raised in the middle on trees, disposed like rafters, after the form of a gable roof.

"This construction, simple as it appears, probably gave birth to most of the parts that now adorn our buildings, particularly to the orders, which may be considered as the basis of the whole decorative part of architecture; for when structures of wood were set aside, and men began to erect solid, stately edifices of stone, having nothing nearer to imitate, they naturally copied the parts which necessity introduced in the primitive hut, insomuch, that the upright trees, with the stones and cordage at each end of them, were the origin of columns, bases, and capitals; the beams and joists gave rise to architraves and friezes, with their triglyphs and metopes; and the gable roof was the origin of pediments, as the beds of materials forming the covering, and the rafters supporting them, were of cornices, with their corona, their mutules, modillions, and dentils."

Such is the account which has been transmitted to us of the origin of these *orders;* and it has sufficed for, and been unhesitatingly received by, all, or the greater part, of our forefathers: but the restless

scepticism of modern times has not spared even this venerable and harmless notion. It is alleged, that it is very improbable that stone should have been the immediate successor of wood, as a building material, the working of this substance being of itself no small acquirement, and not consistent with the rudeness of the time: the employment of brick most probably intervened, and this was actually used at the tower of Babel.* That the Greeks derived their knowledge of this art from Egypt, is generally allowed; but in the large hollowed crown moulding and flat roof of the temples of that country little resemblance is found to this model. Another objection to this hypothesis will be found in the description of the Doric order, where it will be better introduced and understood than in this place.

We will now proceed to the smaller divisions of the orders, called regular mouldings, which are variously disposed in the different orders, and may reasonably be supposed to have had their origin in the ingenuity of man, rather than in any essential, necessary, law in nature or art. These are as follows:



The fillet, listel, annulet, or square.

Astragal, or bead.

Torus, or tore.

Scotia, trochilus, mouth, or casement.

Echinus, ovolo, or quarter round.

Grecian echinus.

Inverted cyma, talon, or ogee.

Cyma recta, or cymatium.

Cavetto, or hollow.

Of these, the Roman ovolo and cavetto are never found in Grecian architecture, nor the Greek echinus in that of the Romans; the rest they possess in common.

The Greek mouldings are chiefly distinguished from the Roman, by being composed of ellipses, and other conic sections, while the Roman are formed of segments of circles. The Greek echinus and

* "And they said to one another, Go to, let us make bricks and burn them thoroughly. And they had brick for stone, and slime had they for mortar."—*Genesis*, chap. xi. ver. 3.

cyma reversa, are also for the most part *quirked;* that is, the contour is returned under the fillet above, as is shewn in the Grecian echinus. In some early specimens of the Doric order a straight line is used instead of the moulding, as in the capital of the portico of Philip, in the island of Delos.

When the projection of these mouldings is required to be greater or less than usual, (which is sometimes the case from peculiarity of situation) the best method of overcoming the difficulty is, to make them of segments of ellipses, by which means it is evident any required projection may be obtained, and the shadows will be such, as not readily to discover the defect.

In places where the composition is unusually higher or lower than the eye, it is sometimes necessary to deviate from the customary manner of executing the mouldings, to make them appear of their proper forms. It is very rarely, however, that an expedient of this kind is necessary, and it should never be resorted to; but when it is, the forms, when closely examined, are very unpleasing.

All the mouldings, except the fillet, admit of decoration; but even in the most enriched profile it is proper to leave some uncarved to prevent confusion, and give a due repose to the composition. It is a fundamental rule in the sculpture of mouldings, to cut the ornaments out of the contour, beyond which nothing should project, as this would inevitably alter its figure.

The fillet may be used at all heights, and in most situations. The torus only in bases. The scotia always below the eye, and between the fillets attached to the torus. The echinus only above the eye, and is fit for supports. The inverted cyma is also used as a supporting member. The cyma recta and cavetto are only fit for crowning mouldings, for which their forms are peculiarly adapted, being incapable of holding water, which must necessarily drop from their extreme points.

Having thus presented the reader with the key to our future language, we proceed to the description of the *orders.*

The orders of architecture are strictly three; the Doric, the Ionic, and the Corinthian, and are found in the greatest perfection in Greece: but the Romans, determined to produce novelty at the expense of excellence, formed out of the first of these, two new orders, one of which they denominated the Tuscan,* and the other, though very dissimilar to the ancient order of that name, they likewise called the Doric.† The Ionic they altered less, but that little was de-

* See Plate VII. B 1. † B 2 is the Greek Doric, and B 3 the Roman


A
a
b
c
d
e
1
2
3
4
5
6
B
C
b
c
d
e
f
g
h
k
i
l
a

cidedly for the worse (considering the orders of the temples of Minerva Polias, and the Ilyssus as the standard of Grecian art.) The Corinthian, they must be allowed to have improved, but formed a variation of it, frequently seen in the Roman buildings, particularly in the triumphal arches, which has been erected by the moderns into a fifth order, under the name of Roman, or Composite. The difference between this and the Corinthian, however, is much less than between the Greek and Roman Doric.

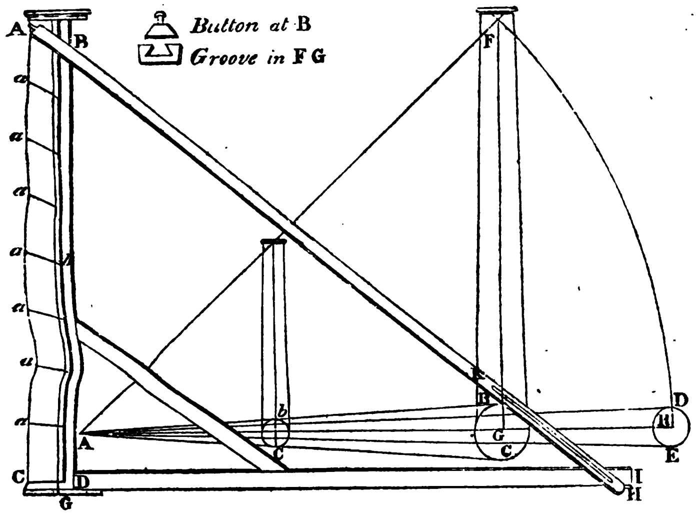
Before we give the orders in detail, it will be necessary to observe, that columns are tapered in their shafts; that is, the circumference of the shaft at the capital is less than it is at the base, thus making a frustrum of a cone; but in most or all of the ancient examples, the line, instead of being perfectly straight, is slightly curved. Sometimes the shaft is continued from the base, cylindrically, to about a quarter or third of its height, and then diminished rectilinearly to the top. This is called *entasis*, and in all the examples of antiquity is so slight as to be scarcely perceptible. Vitruvius having very obscurely hinted at the practice, several of the modern Italian artists intending to conform to his precept, but not perceiving the result in the originals, carried it to an absurd excess, and made the thickness greater at the middle than at the foot of the shaft. As the method of obtaining the true entasis, may be useful and interesting to many of our readers, we here insert it from Sir William Chambers, where it is taken from Blondel, a French architect.

" To give an accurate idea of the operation, it will be necessary first, to describe Vignola's method of diminution, on which it is grounded. ' As to the second method,' says Vignola, ' it is a discovery of my own; and though it be less known than the former, it will be readily comprehended by the figure. Having therefore determined the measures of your column (that is to say, the height of the shaft, and its inferior and superior diameters), draw a line indefinitely from C through D, perpendicular to the axis of the column; this done, set off the distance, C D, which is the inferior semi-diameter, from A, the extreme point of the superior semi-diameter, to B, a point in the axis. Then, from A, through B, draw the line A B E, which will cut the indefinite line, C D in E; and from this point of intersection, E, draw through the axis of the column any number of rays, as E, *b*, *a*, on each of which, from the axis towards the circumference, setting off the interval C D, you may find any number of points, *a*, *a*, *a*, through which if a curve be drawn, it will describe the swelling and diminution of the column.'

"Though this method be sufficiently accurate for practice, especially if a considerable number of points be found, yet, strictly speaking, it is defective; as the curve must either be drawn by hand, or by applying a flexible rule to all the points, both which are liable to variations. Blondel, therefore, to obviate this objection (after having proved the curve passing from A to C through the points *a*, *a*, to be of the same nature with the first conchoid of the ancients) employed the instrument of Nicomedes to describe it, the construction of which is as follows:

"Having determined, as before, the length of the shaft with the inferior and superior diameters of the column, and having likewise found the length of the line C D E; take three rulers, either of wood or metal, as F G, I D, and A H; of which, let F G and I D be fastened together at right angles in G. Cut a dove-tail groove in the middle of F G from top to bottom; and at the point, E, on the ruler, I D, (whose distance, from the middle of the groove in F G is the same as that of the point of intersection from the axis of the column) fix a pin; then, on the ruler, A H, set off the distance A B equal to C D, the inferior semi-diameter of the column, and at the point B is a button, whose head must be exactly fitted to the groove made in F G, in which it is to slide, and at the other extremity of the ruler, A H, cut a slit or channel from H to K, whose length must not be less than the difference of length between E B and E D, and whose breadth must be sufficient to admit the pin fixed at E, which must pass through the slit, that the ruler may slide thereon.

The instrument being thus completed, if the middle of the groove in the ruler, F G, be placed exactly over the axis of the column, it is evident that the ruler, A H, in moving along the groove, will, with its extremity, A, describe the curve A *a a* C, which curve is the same as that produced by Vignola's method of diminution, supposing it done with the utmost accuracy, for the interval A, B, *a*, *b*, is always the same; and the point, E, is the origin of an infinity of lines, of which the parts B A, *b a*, *b a*, extending from the axis to the circumference are equal to each other, and to D C. And if the rulers be of an indefinite size, and the pins at E and B be made to move along their respective ruler, so that the intervals A B and D E may be augmented or diminished at pleasure; it is likewise evident that the same instrument may be thus applied to columns of any size.



THE TUSCAN ORDER.

The Tuscan order, as an antique, exists only in the works of Vitruvius, the description in which, being very obscure, has left a wide field for the ingenuity of modern architects. Among these Palladio composed two profiles;* one from the description of the ancient

* The *profile* of an order, is the representation of its combination of parts and mouldings. The remarks of Sir William Chambers on this subject are so excellent, that though we have often had occasion in the course of our work to introduce his name, we cannot forbear inserting them.

"The most perfect profiles are such as consist of few mouldings, varied both in form and size, fitly applied with regard to their uses, and so distributed, that the straight and curved ones succeed each other alternately. In every profile there should be a predominant member, to which the others ought to seem subservient, and made either to support, to fortify, or to shelter it from injuries of weather; and whenever the profile is considerable or much complicated, the predominant should always be accompanied with one or more other principal members, in form and dimension calculated to attract the eye, create momentary pauses, and assist the perception of the beholder. These predominant and principal members ought always to be of the essential class, and generally rectangular. Thus, in a cornice the corona predominates; the modillions and dentils are principals in the composition; the cyma and cavetto cover them; the ovolo and talon support them."

master,* and the other, according to his own idea of a simplification of the Doric. That of Vignola, however, has been most generally approved and adopted.

The base of this order consists of a simple torus, with its fillet; it is, as are in general all the Roman orders, accompanied by a plinth.

The proportions, from Sir W. Chambers, are as follow: the column, fourteen modules; † the entablature, three modules, fifteen minutes. Of the former, the base occupies one module; the shaft (including the astragal, which divides it from the capital), twelve modules, and the capital one. Of the latter, the architrave (including the fillet), thirty-one minutes and a half; the frieze, the same; and the cornice, forty-two minutes.

The intercolumniations, in all the orders except the Doric, are the same; *viz.* the eustyle, which is most common and beautiful, four modules, twenty minutes; the diastyle, six modules; and the aræostyle, seven modules.

The Tuscan order admits of no ornaments, nor flutes in the columns; on the contrary, rustic cinctures are sometimes represented on the shaft of its column: but this practice, though occasionally used by good architects, is seldom compatible with good taste.

This order may be employed in most cases, where strength and simplicity are required, rather than magnificence; such as prisons, market-places, arsenals, and the inferior parts of large buildings.

THE DORIC ORDER.

We now come to an order, of which numerous ancient examples exist, and which will, in consequence, furnish us with more materials for description than the preceding. We will commence with the story of its origin, as given by Vitruvius.

"Dorus, son of Hellen and the nymph Orseis, reigned over Achaia and Peloponnesus. He built a temple of this order, on a spot sacred

* The principal, and we believe the only important, execution of this idea, is in the portico of St. Paul's Church, Govent Garden, of which the architect was Inigo Jones.

† The module is half the diameter of the column at the foot of the shaft, and is commonly used in describing the dimensions of the orders. Strictly speaking, it is confined in this sense to the Doric, and, in the others, is the whole diameter; but, to avoid confusion, this distinction is little attended to, and is now almost forgotten: for practice, the module is divided into thirty minutes.

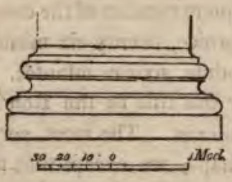
to Juno, at Argos, an ancient city. Many temples similar to it were afterwards raised in the other parts of Achaia, though at that time its proportions were not precisely established." This account, as well of those of the orders which we shall presently examine, is very incredible, and is now generally rejected.

From theory, however, we must now proceed to fact and description, and will commence with the Doric of the Greeks, referred to by Vitruvius (who nevertheless confounds this with what was commonly executed at Rome in his time). The most perfect example, is the order of the Parthenon, or temple of Minerva, in the Acropolis at Athens, erected under the administration of Pericles, who lived about 450 years before the Christian era. It is this which is represented in our Plate (B 2), we shall therefore now give its dimensions. The column (including the capital), ten modules, twenty-eight minutes and a half; the whole entablature, three modules, twenty-seven minutes and three-quarters; the capital, twenty-seven minutes and three-quarters; the architrave (with its fillet), one module, twelve minutes and three-quarters; the frieze, to the square member of the corona, one module, nineteen minutes; and the cornice, twenty-six minutes. Diameter of the column at the top, one module, sixteen minutes.

To proceed to the order, designated by this title by the Romans. Very few ancient examples of this variation exist. The most perfect is that of the theatre of Marcellus, if, perhaps, we except that misshapen pile, Trajan's column, which is generally pronounced to be Tuscan. It is, therefore, principally indebted for its existence to the *modern* Italian architects, who, having little of antiquity before their eyes, appear to have bestowed more attention upon this order than the others, and it must be confessed that they have made of it a very elegant design, though, as before observed, essentially different from the original and true Doric. The measures, from Sir William Chambers, are as follow: The base, thirty minutes; the shaft, thirteen modules, twenty-eight minutes; and the capital, thirty-two minutes; the architrave, thirty minutes; the frieze to capital of triglyph, forty-five minutes; and cornice, forty-five minutes. Upper diameter of column, fifty minutes.

In no example of antiquity is the Doric column provided with a base. This circumstance has occasioned no small perplexity to some of those fanciful writers, who seek in every point some analogy to the human figure, or the trunk of a tree. Vitruvius, indeed, has told them that the base is a *shoe*, first invented to cover the nakedness of the matronly prototype of the Ionic order. "But," says Monsieur

Le Clerc, "I must own I cannot consider a column without a base, comparing it to a man, but I am, at the same time struck with the idea of a person without feet, rather than without shoes; for which reason I am inclined to believe, either that the architects had not yet thought of employing bases to their columns, or that they omitted them in order to leave the pavement clear, the angles and projection of bases being stumbling blocks to passengers, and so much the more troublesome, as the architects of those times frequently placed their columns very near each other, so that, had they been made with bases, the passages between them would have been extremely narrow and inconvenient." Accordingly, to supply this defect, as it was considered in this order, most architects have employed the *attic base*, which is common to all the orders except the Tuscan, though belonging, perhaps, more peculiarly to the Ionic. We have, therefore, here given a representation of it from Vignola, after which, little explanation will be necessary.



It is seen that it consists of two tori, with a scotia and fillets, between the upper of which, in this version, resembles an inverted ovolo. The fillet, above the upper torus, is always connected with the shaft by a curve, as is also that under the capital, for which reason they are commonly considered as part of the shaft. The *plinth*, or square member beneath, is usually understood, in Roman architecture, as an indispensable appendage to the base, though Palladio has omitted it in his Corinthian order; but it is rarely found in the Greek specimens. To save this order, however, from the sad humiliation of being obliged to borrow a shoe when required to wear one, Vignola provided it with this appendage. His base consists of one large torus, with one considerably smaller resting upon it, surmounted by the fillet.

M. Le Clerc has, however, we apprehend, discovered the true reason why, at least in the latter Greek specimens, the base is omitted; namely, the very narrow intercolumniations. In the Greek order alteration is not probable, and perhaps not desirable; but in the Roman, where this addition has been long provided for us, and the intercolumniations adjusted accordingly, the omission would be certainly improper.*

* Due allowance must, in all such cases, be made for prejudice and habit, for these are, in truth, the only criterions of beauty, unconnected (as in archi-

The most striking peculiarity in this order, is the ***triglyph***, (supposed by Vitruvius to be the end of the joists, laid transversely on the beam of the architrave), which forms the technical distinction between the Grecian and Roman Doric, being in the former always placed at the corner of the entablature, and in the latter, invariably over the centre of the column. (See Plate.) This circumstance is a corroboration of the objection against the notion of the timber prototype, for, following the idea of the Egyptian origin of Greek architecture, there is found in the large hollowed crown moulding of the temple of Tentyris (see Plate), a decoration very similar to the Doric triglyph, the extreme parts of which are placed at the angle, like the Greek Doric, but which, from their situation, bear not the least resemblance to the ends of pieces of wood.* The triglyph is surmounted by the *mutule*, in the Greek, and in some Roman examples inclined, but in most modern profiles horizontal: on its soffit are represented guttæ, or drops. The spaces between the triglyphs on the frieze, are called metopes, which, in the modern Doric, are invariably perfectly square, and generally enriched with sculptures. Those which formerly adorned the metopes of the Parthenon were brought to this country

tecture) with natural objects. A lovely female alike fascinates the pampered voluptuary, and the untutored savage; though different causes, arising from cultivation of intellect, may operate in this preference: the grand and beautiful features of nature, the gracefully irregular tree, the rugged rock, the overwhelming wave, and the rushing cataract, likewise fill with emotion every breast. But the hardy inhabitant of the forest would, perhaps, laugh at our boasted rules of proportion, those exquisite niceties and nameless beauties, which form the subject of the panegyric of the connoisseur; as men more civilized have derided the simple elegance of Grecian art, and the sublime grandeur of the architecture of our ancestors. The inference is, that there is no such thing as inherent beauty in any thing unconnected with the immediate gratification of the senses, or excitation of the passions, and we must be content, after all, with the acknowledgment, that our "sublime science," our "heaven descended proportions," are nothing more than ideal beauties to tickle the fancies of our employers, and that the quality on which the architect must principally found his claim to honour, is mathematical skill.

* We have stated these objections, as they have been lately suggested by Mr. Gwilt; but the writer is inclined to believe, from many circumstances, that if the timber hut was not the actual precursor of the Grecian temple, it was at least consulted in the arrangement, *i. e.* allowing the latter to have been originally brought from Egypt, the Greeks joined with it the semblance of the hut, which appears to be the only way of accounting for the angular triglyph, joined with the inclined mutule, the open metope (as it was originally), and the numerous evidences in favour of this origin. The Romans afterwards, perfecting this idea, altered the situation of the triglyph, in our opinion much for the worse.

by Lord Elgin, and now form the principal part of the collection which is known by his name at the British Museum. In the modern order these sculptures are most commonly an alternate bull's scull, and patera. The extreme projections of all these ornaments should be less than that of the triglyph itself, thus keeping a due subordination between mere decorations and essential parts. All the Grecian Doric columns are fluted, and in both Greek and Roman this is performed without fillets between, as in the other orders. The intercolumniations in this order differ from those of the others, on account of the triglyph, the metopes being required to be exactly square. They are as follow: the coupled columns of course must stand under adjoining triglyphs; this makes their distance, at the foot of the shaft, twenty-one minutes. The next intercolumniation is the monotriglyph, having *one* between the columns; the distance is three modules. The diastyle—two triglyphs, five modules and a half. The aræosistile, which has three between, eight modules. This last is a size which should never be resorted to but in cases of great necessity, and indeed is seldom practicable.

The following table of proportions of this order, is extracted from Aikin's " Essay on the Doric order."

TABLE OF PROPORTIONS.

Names of Examples.	Bottom Diameter.	Top Diameter.	Height of Column.	Architrave.	Frieze.	Cornice.	Intercolumniation
Portico of the Agora, at Athens ..	60 min.	47 min.	6 diam. 2½ min.	40 min.	42 min.	21 min.	—
Temple of Minerva, at Sunium	60 —	45¾ —	5 — 54 —	48½ —	48½ —	—	1 diam. 28 min.
Temple of Jupiter, Nemæus	60 —	49 —	6 — 31 —	38⅔ —	43½ —	—	—
Temple of Jupiter, Pannellenius ..	60 —	44½ —	5 — 24 —	51⅓ —	51½ —	—	1 — 41 —
Temple of Theseus	60 —	46⅔ —	5 — 42⅛ —	50 —	49½ —	—	1 — 37½ —
Temple of Minerva, at Athens	60 —	47 —	5 — 33½ —	43 —	43 —	32 —	1 — 17⅔ —
Temple at Corinth...............	60 —	44⅔ —	4 — 4 —	48⅔ —	—	—	1 — 14 —
Portico of Philip	60 —	49½ —	6 — 32½ —	38⅓ —	43¾ —	25½ —	2 — 42⅔ —
Temple of Apollo	60 —	42½ —	6 — 3¾ —	49⅔ —	42½ —	—	—
Temple of Minerva, at Syracuse ..	60 —	46 —	4 — 24½ —	44½ —	40 —	—	1 — 5⅔ —
Temple of Juna Lucina	60 —	45⅓ —	4 — 42 —	55 —	45 —	—	1 — 15 —
Temple of Concord	60 —	46 —	4 — 45¼ —	46⅘ —	46⅛ —	25 —	1 — 10⅔ —
Pseudo-depteral temple at Pæstum	60 —	40⅓ —	4 — 27 —	50 —	—	—	59½ min. 67⅔ —
Hexastyle temple at Pæstum......	60 —	43 —	4 — 47¾ —	45¾ —	44¾ —	24¾ —	1 diam. 1⅛ —
Hypæthral temple at Pæstrum	60 —	41¼ —	4 — 8 —	42⅛ —	40½ —	21½ —	1 — 4¾ —
Inner peristyle of ditto	60 —	43 —	4 — 13⅓ —	39 —	—	—	1 — 22¾ —
Upper columns of ditto ditto	60 —	44⅓ —	3 — 50 —	68 —	—	—	2 — 49 —
Temple at Selinus...............	60 —	46 —	4 — 21⅚ —	46⅛ —	44⅔ —	—	—
Temple of Jupiter, at Selinus	60 —	35½ —	4 — 34⅛ —	52 —	44⅔ —	26 —	—
Temple at Egesta................	60 —	44¾ —	—	49¾ —	52⅔ —	40¾ —	1 — 11 —
Theatre of Marcellus	60 —	48 —	7 — 51⅔ —	30 —	45⅚ —	37⅝ —	—

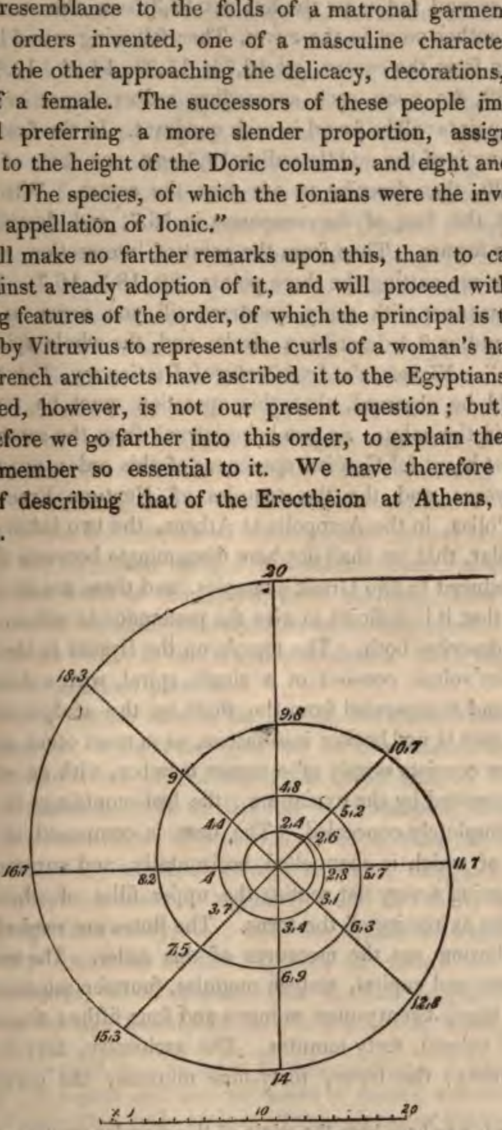
"The ancients," says Sir William Chambers, "employed the Doric in temples dedicated to Minerva, to Mars, and to Hercules, whose grave and manly dispositions suited well with the character of the order. Serlis says, it is proper for churches dedicated to Jesus Christ, St. Paul, St. Peter, or any other saints remarkable for their fortitude, in exposing their lives, and suffering for the Christian faith. Le Clerc recommends the use of it in all kinds of military buildings; as arsenals, gates of fortified places, guard rooms, and similar structures. It may likewise be employed in the houses of generals, or other martial men; in mausoleums erected to their memory, or in triumphal bridges and arches built to celebrate their victories."

THE IONIC ORDER.

THE account of this order, which is given by Vitruvius, informs us, that in a general assembly of the Grecian states, thirteen colonies were sent over into Asia, by the Athenians; the expedition being led by Ion, whom the Delphic oracle which directed the emigration had acknowledged for the offspring of Apollo. They settled on the borders of Caria, and built several cities of great fame, of which were Ephesus, Miletus, Samos, and Colophon, to which Smyrna was afterwards added: and after the expulsion of the original inhabitants, these colonies were denominated Ionian, from the name of their chief. "In this country," continues he, "allotting different sites to sacred purposes, they erected temples, the first of which was dedicated to Apollo Panionius. It resembled that which they had seen in Achaia, and, from the species having been first used in the cities of Doria, they gave it the name of Doric. As they wished to erect this temple with columns, and were not acquainted with their proportions, nor the mode in which they should be adjusted, so as to be both adapted to the reception of the superincumbent weight, and to have a beautiful effect; they measured a man's height by the length of the foot, which they found to be a sixth part thereof, and thence deduced the proportion of their columns. Thus the Doric order borrowed its proportion, strength, and beauty from the human figure. On similar principles they afterwards built the temple of Diana, but in this, from a desire of varying the proportions, they used the female figure as a standard, making the height of the column eight times its thickness, for the purpose of giving it a more lofty effect. Under this new order they placed a base as a shoe to the foot. They also added volutes to the capital, resembling

the graceful curls of the hair, hanging therefrom to the right and left certain mouldings and foliage. On the shaft, channels were sunk, bearing a resemblance to the folds of a matronal garment.* Thus were two orders invented, one of a masculine character, without ornament, the other approaching the delicacy, decorations, and proportion of a female. The successors of these people improving in taste, and preferring a more slender proportion, assigned seven diameters to the height of the Doric column, and eight and a half to the Ionic. The species, of which the Ionians were the inventors, received the appellation of Ionic."

We shall make no farther remarks upon this, than to caution the reader against a ready adoption of it, and will proceed with the distinguishing features of the order, of which the principal is the *volute*, supposed by Vitruvius to represent the curls of a woman's hair. Some modern French architects have ascribed it to the Egyptians. Where it originated, however, is not our present question; but it will be proper, before we go farther into this order, to explain the construction of a member so essential to it. We have therefore given the method of describing that of the Erectheion at Athens, from Mr. Nicholson.



* All the Grecian Doric columns have flutes; a fact Vitruvius does not appear to have been aware of.

"The centre is marked by the point · upon the cathetus. Set 20 from · upwards, which will give the extremity of the first radius. Upon the second radius to the left set 18,3 from the centre, which will give another point in the curve. Then following round in the same progression from the centre, set 16,74, 15,32, 14.01, 12.82, 11.73, 10,73, 9.82, &c. upon each succeeding radius respectively to 2.37, and three points will be found in each quadrant. In the first quadrant, take the length of the middle radius 18,3, set one foot of the compasses in 20, then describe an arc near the centre. With the same radius, set the foot of the compasses in 16.7, and describe an arc cutting the former. Then from the point of intersection, as a centre, describe an arc cutting the three points, 20, 18.3, 16.7. Proceed in the same manner with every quadrant till you arrive at 2,4, then with the radius 2.4 describe a circle, and the whole spiral will be completed."—*Nicholson's Architectural Dictionary, Volute.*

It should be observed, that this operation must be repeated for every line in the volute, no two being struck from the same centre.

The most beautiful Grecian specimens of this order, are the temple on the Ilyssus, and the the temples of Neptune Erectheus, and Minerva Polias, in the Acropolis at Athens, the two latter of which are so similar, that we shall not here discriminate between them. We are thus reduced to two Greek examples, and these are so exquisitely beautiful, that it is difficult to give the preference to either. We shall therefore describe both. The temple on the Ilyssus is the plainer of the two: its volute consists of a single spiral, with a deep channel between, and is separated from the shaft by the sculptured echinus. The architrave is not broken into fasciæ, as in most other specimens.* The cornice consists simply of a square member, with an echinus and fillet, surmounted by the cymatium: the bed-mouldings in the elevation are completely concealed. The base is composed of two tori, the upper of which is channelled horizontally, and surmounted by a bead, inclosing a very flat scotia, the upper fillet of which projects as far as the extremity of the torus. The flutes are semi-elliptic.

The following are the measures of this order. The column, including base and capital, sixteen modules, fourteen minutes and one-fifth; the base, twenty-nine minutes and four-fifths; the capital (to bottom of volute), forty minutes. The architrave, fifty-five minutes and two-fifths; the frieze, forty-nine minutes; the cornice, thirty

* Whatever may have been the origin of this singular practice, *viz.* making the fasciæ of the architrave to overhang each other, we cannot but consider it as very absurd, and the greatest defect in Grecian architecture.

minutes and one-fifth. Width of the capital, three modules, three minutes; upper diameter of column, fifty-one minutes. Intercolumniation from centre to centre of column, six modules, five minutes and two-fifths.

The order of the temple of Minerva Polias is next to be considered. This example is much richer, yet no less elegant than the other: the volute, instead of a single spiral, is formed by three: the sculptured echinus beneath is surmounted by a guilloched moulding, and separated from the shaft by a neck adorned with honey-suckles. The base is very similar to that of the temple on the Ilyssus, except that its beauty is increased by the diminution of its height, the scotia is deeper, and the upper torus is guilloched. The architrave consists of three fasciæ, and the cornice is similar to that of the Ilyssus temple, except that the echinus and bed-moulding are sculptured, and the astragal of the latter is seen in the elevation beneath the corona.*

The column, including base and capital, is eighteen modules, seven minutes and one-tenth in height; the base, twenty-four minutes; and capital, forty-two. The architrave, forty-five minutes and one-fourth; the frieze, forty-seven minutes and four-fifths; and cornice, (to the fillet of the echinus, which is the greatest *actual* height of the entablature, the cymatum being a restoration), twenty minutes and two-fifths. The width of the capital, three modules, three minutes. Upper diameter of column, forty-nine minutes and a half. Intercolumniation, (from centre to centre), nine modules. Both these orders are destitute of insulated plinths.

Having thus given our readers an idea of the finest Greek specimens of this order, we must now proceed to the Roman and Italian version of it. It is the peculiarity of this order, that its front and side faces are dissimilar. To obviate this inconvenience, the Greeks twisted the extreme volutes of a portico so as to make the two faces alike. But Scamozzi, a famous Italian architect, designed a capital in which the volutes proceeded angularly from the shaft, thus presenting the same front every way; and the capital so executed has been generally attributed to the supposed inventor. Sir William Chambers, however, is of opinion, that Michael Angelo was the author of one of this description in the Vatican at Rome.† This

* This is most beautifully executed at St. Pancras church, at the east end; in the interior the capital and base are carved in marble, with the shaft of scagliola work resembling verde antique. In the portico of this church that of the Erectheion is copied.

† This may be seen in the beautiful circular portico of All Souls' church, built by Mr. Nash in Langham Place.

capital is commonly known as the modern Ionic, but has not been often executed in large works. The frieze of this order has been, by many architects, and Palladio among the number, pulvinated, or rounded in its contour, and smaller than the architrave, as though it were pressed down and bent by the superincumbent weight; but the ill effect of this has been so generally perceived, that it is rarely to be seen in late works. The cornice is distinguished from the Greek by its variety of mouldings, among which the most remarkable is a square member in the bed-mouldings, cut into small divisions, somewhat resembling teeth, whence they are called *dentils.* In other points of variation between the Grecian and Roman achitecture there may be a difference of opinion, but with respect to the Ionic capital, we conceive this to be impossible. Whoever compares the meagre, petty form of the capital of the temple of Concord, with that of the Erectheion, must instantly, whatever be his former prejudices, perceive the amazing difference, and unhesitatingly acknowledge the vast superiority of the latter. The poverty of the solitary revolving fillet, the flat, insipid lines, and the enormous projection of the clumsy echinus, combine to render this the very worst feature in all the Italian orders. The base commonly used is the Attic, though Vitruvius has appropriated one to this order, resembling the Corinthian without its lower torus.

The following are the measures of the order, from Sir William Chambers. The base, one module; the shaft, sixteen modules, nine minutes; and capital, twenty-one minutes. The architrave, forty minutes and a half; the frieze, the same; and cornice, fifty-four minutes. Width of capital, two modules, twenty-six minutes. Upper diameter of column, fifty minutes.

" As the Doric order," says Sir William Chambers, " is particularly affected in churches or temples dedicated to male saints, so the Ionic is principally used in such as are consecrated to females of the matronal state. It is likewise employed in courts of justice, in libraries, colleges, seminaries, and other structures having relation to arts or letters; in private houses, and in palaces; to adorn the women's apartments, and, says Le Clerc, in all places dedicated to peace and tranquillity. The ancients employed it in temples sacred to Juno, to Bacchus, to Diana, and other deities whose characters held a medium between the severe and the effeminate."

THE ROMAN, OR COMPOSITE ORDER.

THIS order (though not considered by them as a distinct one) was employed by the Romans principally in Triumphal arches, the column

and entablature being the same as, or little differing from, the Corinthian.

This difference was, however, sufficient for the Italians to ground a new order upon. The capital, as being *composed* of the Ionic and Corinthian, they termed *composite*, and to justify the application of the name to the order in general, they combined in the entablature the dentils of the Ionic with the mutules of the Doric, and enrichments of the Corinthian, and gave to the architrave but two fasciæ, thus rendering it in some respects more simple, but more enriched than the latter, while the former had little but the name left in the composition. The whole order may be safely pronounced to be heavy, without possessing grandeur, and rich, though destitute of beauty. It has not been frequently adopted, and it is to be lamented, that Sir Christopher Wren has made so much use of it about St. Paul's.

The base commonly appropriated to this order is extremely beautiful: it consists of two tori, (the lower of which is considerably the larger), with two scotiæ, enclosing an astragal. This is called the *proper* base of the order, but the Attic is usually employed, being more simple, and consequently less expensive than the other.

The measures of this order, from Sir William Chambers, are as follow: The base, thirty minutes; the shaft, sixteen modules, twenty minutes; and capital, two modules, ten minutes. The architrave, forty-five minutes; the frieze, forty-five minutes; and the cornice, two modules.

THE CORINTHIAN ORDER.

The story of the origin of this order, given by Vitruvius, is as follows: "The third species of columns, which is called Corinthian, resembles in its character the graceful, elegant appearance of a virgin, whose limbs are of a more delicate form, and whose ornaments should be unobtrusive. The invention of the capital of this order arose from the following circumstance. A Corinthian virgin, who was of marriageable age, fell a victim to a violent disorder: after her interment, her nurse, collecting in a basket those articles to which she had shewn a partiality when alive, carried them to her tomb, and placed a tile on the basket, for the longer preservation of its contents. The basket was accidentally placed on the root of an acanthus plant, which, pressed by the weight, shot forth towards spring in stems of large foliage, and, in the course of its growth, reached the angles of the tile, and thus formed volutes at the extremities. Callimachus, who

for his great ingenuity and taste in sculpture was called, by the Athenians, κατατεχνος, happening to pass by the tomb, observed the basket, and the delicacy of the foliage which surrounded it. Pleased with the form and novelty of the combination, he took the hint for inventing these columns, and used them in the country about Corinth, regulating by this model the manner and proportion of the Corinthian order.

It has been before observed in our notice of Egyptian architecture, that the capitals to be found in that country are much more likely to have given the hint for the Corinthian than the circumstance here mentioned The only pure example of this order in Greece is the monument of Lysicrates. The capital of this specimen is exquisitely beautiful, but the same praise cannot, in the opinion of the writer, be justly awarded to the entablature: the architrave is disproportionately large, and the frieze extremely small; the bed-mouldings of the cornice (which completely overpower the corona) consist of large dentils, supported by the echinus, and surmounted by a cyma recta under a cyma reversa, which supports the corona. The base is extremely beautiful, resembling that of the temple of Minerva Polias, except that an inverted echinus is substituted for the upper torus: the base stands upon a large inverted cavetto, connected with the continued plinth by another inverted echinus. The flutes terminate upwards in the form of leaves, instead of being divided from the capital, as usual, by an astragal. The building is circular, and its centre is the summit of an equilateral triangle, of which the base is a line bounded by the centres of any two of the columns: the intercolumniation is six modules, thirteen minutes and one-fifth. Height of the column, twenty modules, thirteen minutes and two-fifths, of which the base occupies twenty-one minutes; and the capital, two modules, twenty-seven minutes. The architrave, fifty-three minutes and two-fifths; the frieze, forty-one minutes and two-fifths; and the cornice forty-eight minutes and four-fifths. The finest Roman example of this order, is that of three columns in the Campo Vaccino, at Rome, which are commonly considered as the remains of the temple of Jupiter Stator. This example has received the commendation of all modern artists, yet has seldom been executed in its original form. This is probably owing to the excessive richness and delicacy of it, which renders its adoption very expensive, and perhaps the modification of it by Vignola is preferable to the original, possessing a sufficient enrichment without the excessive refinement of the other. In this order (which has been adopted by Sir William Chambers) the base is one

module in height; the shaft, sixteen modules, twenty minutes; and the capital, two modules ten minutes; thus giving ten diameters to the whole column. The architrave and frieze are each one module, fifteen minutes in height, and the cornice, two modules. The cornice is distinguished by modillions interposing between the bed-mouldings and corona; the latter is formed by a square member surmounted by a cymatium supported by a small ogee: the former is composed by dentils, supported by a cyma reversa, and covered by the ovolo. When the order is enriched, which is usually the case,* these mouldings, excepting the cymatium and square of the corona, are all sculptured: the column is also fluted, and the channels are sometimes filled to about a third of their height with cablings, which are cylindrical pieces let into the channels. When the column is large, and near the eye, these are recommended as strengthening them, and rendering the fillets less liable to fracture; but when they are not approached it is better to leave the flutes plain. They are sometimes sculptured, but this should be only in highly enriched orders.

The flutes are twenty-four in number, and commonly semicircular in their plan. The Corinthian base is similar to that of the composite order, excepting that two astragals are employed between the scotiæ instead of one; but the Attic is usually employed for the reasons before assigned.

"The Corinthian order," says Sir William Chambers, "is proper for all buildings where elegance, gaiety, and magnificence are required. The ancients employed it in temples dedicated to Venus, to Flora, Proserpine, and the nymphs of fountains, because the flowers, foliage, and volutes with which it is adorned seemed well adapted to the delicacy and elegance of such deities. Being the most splendid of all the orders, it is extremely proper for the decoration of palaces, public squares, or galleries and arcades surrounding them; for churches dedicated to the Virgin Mary, or to other virgin saints, and on account of its rich, gay, and graceful appearance it may, with propriety, be used in theatres, in ball or banqueting rooms, and in all places consecrated to festive mirth, or convivial recreation."

PERSIANS AND CARYATIDES.

Having now described what are called the regular orders, it is necessary to notice, in the next place, the employment of human figures

* When expense is an object, it is much better to employ one of the plainer orders than to strip the Corinthian of all its beauty. The ill effect of this order, unadorned, may be seen at St Mary-le-bone church.

instead of columns for the support of an entablature. We will first give, as in former cases, the account of Vitruvius. "Carya, a city of Peloponnesus, took part with the Persians against the Grecian states. When the country was freed from its invaders, the Greeks turned their arms against the Caryans, and upon the capture of the city, put the males to the sword, and led the women into captivity. The architects of that time, for the purpose of perpetuating the ignominy of this people, instead of columns in the porticos of their buildings, substituted statues of these women, faithfully copying their ornaments, and the drapery with which they were attired, the mode of which they were not permitted to change."

There are two great objections to the truth of this story: first, that the circumstance is not mentioned by any of the Grecian historians; and secondly, that it is certain animal figures were employed for this purpose long previous to the time assigned by Vitruvius.

Having thus shewn our readers what is *not* the origin of these figures, it must next be our business to inform him what *is*, or rather what is most probable, and for this purpose we must trespass on the kindness of Mr. Gwilt, the only writer, we believe, who has given a satisfactory account of them.* He conjectures the name to have arisen from the employment of them in temples to Diana, who is supposed to have made the Lacedemonians acquainted with the story of Carya (turned into a nut tree by Bacchus, who also transformed her sisters into stones), and thence worshipped by them under the name of *Caryatis*. Thus, being first employed in temples to this goddess, they afterwards came into use in other buildings as representations of the nymphs who assisted at the mysteries of the patron goddess. They may be seen at St. Pancras church, correctly copied from the Pandroseum, the only Greek building remaining where they are employed.†

The entablature of this example is extremely heavy, consisting only of an architrave and enormous cornice with dentils, which, however disproportionate in its situation, is of itself very beautiful. There are no remains of these figures in ancient Rome. The moderns have

* In a private pamphlet, printed in 1821, and afterwards incorporated in his Essay on Grecian Architecture prefixed to his edition of the treatise of Sir William Chambers.

† The Pandroseum is attached to the temples of Neptune Erectheus, and Minerva Polias, in the Acropolis at Athens, which have been before described, and from which St. Pancras church is copied. The only excuse that can be made for their introduction in a Christian church.

assigned the Ionic entablature to Caryatides, and the Doric, when the figures of men are employed, which are called Persians.

Caryatides are, when appropriately designed, well adapted for buildings devoted to pleasure, such as theatres, ball rooms, &c. but are decidedly improper for sacred edifices. They should not be represented much above the natural size, " lest they should appear hideous in the eyes of the fair."

For male figures, on the contrary, a large size is desirable: they are said to be proper for military buildings.

The contradictions of some of the French architects on this subject are very curious. Le Clerc tells us, that it is very wrong to represent Caryatides in servile attitudes, such characters being very injurious to the sex. On the contrary, they should be considered as the greatest ornaments of buildings, as their prototypes are of creation, and represented in respectful characters.

But M. De Chambrai disagrees with his learned friend, and considers this practice as an error, observing, that if the text of Vitruvius be attended to, it will be perceived that it is very improper to represent saints and angels loaded like slaves with cornices and other heavy burdens. He likewise considers them as improper for churches, in which, as houses of God and asylums of mercy, vengeance and slavery ought never to appear.

M. Blondel again observes, " that though this remark be just, if the origin of these ornaments be rigorously attended to, yet to serve in the house of God, and particularly at the altar, has always appeared in the minds of the prophets and saints so glorious and great, that not only men, but angels, ought to esteem it a happiness, and that consequently it can be no indication of disrespect to employ their representations in offices in which they would themselves execute with pleasure.

Such are the empty questions and debates into which blind reverence for antiquity has involved men of considerable talents. Leaving them, however, to such as are more inclined to pay them attention, it is now requisite to describe a species of figures, which, on account of its simplicity, has sometimes been substituted for Caryatides. These are called Termini, or terms, and derive their name and origin from the boundary stones of the Romans, to render which inviolate, Numa Pompilius erected the Terminus into a deity, and he was first worshipped in the similitude of a stone. This was afterwards improved into a human head upon a pedestal, smaller at the bottom

than the top, and they are thus, with numerous variations, represented in buildings.

PILASTERS.

Pilasters are square pillars attached to walls, in every other respect resembling columns. They were unknown to the Greeks: the antæ, which somewhat resemble them, being merely projections in the walls, with bases and capitals, different to the columns, to receive the architrave. Pilasters are employed instead of columns in interior decorations, to save room and expense, and frequently in exterior compositions. When used as principals, that is, when columns are not employed in the same composition, they should project one-quarter of their diameter, unless the cornices of windows of greater projection are divided by them, in which case they must be increased to meet the necessity. When in a line with columns the projection must be regulated by them.

Respecting the diminution of pilasters the greatest architects are at variance. Where they are employed with columns, it is certainly proper to make them correspond, and where they are alone it is perhaps most desirable; as either the capitals will be of an unusual size, or the pilasters themselves inelegantly thin, when they are rectilinear.

In the Tuscan and Doric orders there will be no difficulty in the execution of the capitals on a flat surface; but in the Ionic, on account of the great projection of the echinus, it is necessary either to bend it inwards considerably at each end, that it may pass behind the volutes, or to twist these forwards to hide the passage of the echinus. The latter expedient is considered the best. In the angular Ionic, and in the Composite, the volutes may be spread out so as to cover the echinus, and in the Corinthian the bell must present the segment of a circle in front.

PEDESTALS.

In the use of columns they are most frequently placed in the ground, but are sometimes raised on insulated basements, called pedestals. A pedestal is, like a column, composed of three parts; the base, the body or die, and the cornice, the decorations of which vary according to the order in which it is employed. The best method of arranging them is that employed by Vignola, who makes them in all the orders

one-third of the height of the column, thus preserving the character of the order. The die is always the same size as the plinth of the column, and the base and cornice are regulated by the delicacy of the order.

Pedestals should never be employed with detached columns, forming porticos, but they are frequently applied to columns which divide arches, and are necessary in churches, where the pews would otherwise conceal the base, and great part of the column. The same reason will justify their use in all edifices built for the reception of crowded assemblies.

PEDIMENTS.

WHEN columns are employed to decorate the gable of a building, in which situation they usually form what is called a portico, the triangle formed by the roof projecting upwards from the entablature, is called a pediment. The entablature, in this case, is covered by two straight inclined cornices, the mouldings of which are similar to the horizontal one: the space inclosed is called the tympanum. This was the original pediment, and the only form found in Greece; but the Romans, to vary the form, employed, in smaller works, a segment of a circle instead of the triangle. The latter form, however, is heavy, and is only used as coverings to gates, doors, windows, and such smaller architectural works, where, by reason of their diminutiveness, they may produce variety without being disagreeable to the eye. The cymatium, when the horizontal cornice is covered with a pediment, is omitted, and only used in the inclined cornice, otherwise this moulding would occur twice together in the same profile. The mutules, dentils, and modillions in the inclined or segmental cornice, must always answer perpendicularly to those in the horizontal one, and their sides perpendicular to the latter.

The proportion of a pediment depends upon the width of the base, the cornice being always of the same size: thus, in a portico with many columns, the tympanum will bear a very different proportion to the rest of the composition when it is composed by few The method of determining the height of a pediment has lately been given in a French pamphlet more correctly than before; it is as follows: From the summit of an equilateral triangle, of which the base is the upper fillet of the horizontal cornice, with one side of the triangle as a radius describe an arc. With the point of intersection between this arc and the centre line of the composition as a centre,

and with the depth of the horizontal cornice as a radius, describe a part of a circle. A line drawn from the extreme boundary of the upper moulding of the horizontal cornice, passing as a tangent, the circle gives the inclination of the pediment.

Having now described all the essential parts of Grecian and Roman architecture, it becomes our duty, in pursuance of our plan, to give some account of the next style, commonly known by the name of

GOTHIC ARCHITECTURE.*

It has been before observed, that the rude buildings of the Saxons and Normans in this country, which are evidently copied from those of the Romans, may, by gradual improvement, have given rise to Gothic architecture; and that this was the case in England at least there is no doubt. But there are certain peculiarities even in these crude and imperfect attempts (though afterwards more fully developed) which require to be noticed before we proceed further, plainly indicating that the works in question were raised under the influence of a less ardent sun, and more obscured sky. In the happy climate of Greece, where little was to be feared from change of weather, the temples (the only buildings much distinguished for architectural excellence) were frequently destitute of covering. Windows, in this case, being entirely superfluous, the walls were, in many instances, pierced only by a single door, which served at once for ingress and egress both to priests and worshippers. Science here, therefore, was not needed, and indeed is not to be found. With the practical application of the principle of the arch the Greeks do not appear to have been acquainted; the large stones, which in those early ages were to be procured in abundance, being sufficient to cover the columns and the opening of the doors. As architecture improved, however, roofs were added to these edifices, and to throw off the rain they were inclined downwards from the centre to the extremities. This inclination, in a

* The use of this term has been severely reprobated by many modern writers, and they have proposed a variety of new ones in the hope of superseding it; but it does not appear to the present writer that a name is of such vast importance. No one ever thought (who ever thought about it) that the Goths were the inventors of the style; and while its beauties are acknowledged, it can matter little whether we denominate it English, Saracenic, Romanesque, or distinguish it by any other designation which has been, or may be applied to it. The name of Gothic is most common, and that by which the style is best known, for which reason we have here adopted it.

climate where so little rain or snow fell, required to be but small; but in Rome, which is more northern, it was found convenient to increase it to meet the exigencies of the situation. In countries far more exposed to vicissitudes of weather than either of these, it is evident that a very different pitch will be requisite, and this theory is verified by the buildings of northern climates, the architects of which, though totally unacquainted with the works of their southern predecessors, by a singular coincidence adapted their roofs to their latitude in a regular scale of gradation from them.* The Saxon and Norman architects, though they did not comprehend this principle in the perfection to which it was afterwards carried, were sensible of the wants of the climate, and made their roofs much higher than those of their Roman prototypes.

This circumstance presenting itself to minds so quick to perceive, and so able to adopt, any novelty which came recommended by utility and beauty as those of the architects of the middle ages, could not fail of meeting with the highest attention. It was soon seen that unbroken vertical lines and lofty buildings were necessary to harmonize with the high pitched roof, and the pointed arch is but a natural and easy deduction from these *data*.

But there is another and an important peculiarity to buildings designed for northern climates, to which we must next call the reader's attention. This arises from the numerous circumstances which, in these regions, conspire to obscure the rays of the sun. The great darkness which prevails in them, compared with the countries of Greece and Italy, evidently requires a very different arrangement in the public buildings, and this circumstance has received no small share of the attention of the architects whose works we are considering. The variety and beauty of its windows is not the least striking peculiarity of Gothic architecture, and indeed they form the readiest criterion for distinguishing the several styles, as we shall see hereafter.

A third essential point of distinction between this style and all others, consists in the different *purposes* for which the edifices in which it is most apparent were constructed, and the different *ceremonies* for which they were adapted. Although the rites of Greek and Roman paganism were numerous and splendid, they required little aid from architecture: the ceremonies with which they were con-

* This has been lately shewed by an ingenious French writer in the "*Encyclopedie Methodique*," who having formed a scale from the Greek and Roman buildings, found the Gothic buildings in Germany to tally exactly with what the former would have been in such situations.

nected were principally performed in the open air, and the temple was only used as a receptacle for the statue of the Deity, before which sacrifices were offered, and prayers preferred to it.

But Christian worship under papal guidance, and in a country where the atmosphere was so cold as to render shelter requisite for the performance of its ceremonies, required other arrangements in the edifices dedicated to it: for its numerous and splendid processions, was provided a long, narrow, and lofty gallery, called *the nave;* for the reception of the multitude to witness these, adjacent wings were added, called *aisles.* A *choir* was added for the actual performance of the sacred rites, and numerous *chapels* to commemorate the bounty of individuals were dispersed about the edifice.

All these essential appendages necessarily occupied a space of great magnitude, and the figure of the *cross,* held by the Romish Church in the most profound veneration, was pitched upon to regulate the general form of the building thus constituted. Our reason for mentioning these particulars is, to shew the absolute necessity which thus arose for a degree of science and mathematical knowledge, not dreamt of by the architects whose works are received as the sole standards of excellence by most of the professors of modern times. The narrow intercolumniations of the Grecian buildings would have been ill adapted for the display of feudal magnificence, and the stones within the reach of the builders were far too small to have covered even these. Thus the arch became unavoidably a prominent feature in the style. To give greater magnificence to the nave it was made a story higher than the aisles. The wall of this upper story is supported by a tier of arches supported by large piers, which divides the nave from the aisles. The upper, or *clere* story, as it is called, has windows answering to those beneath. To form an interior roofing which should at once hide the timbers above and furnish an appropriate finish to the architecture, the same contrivance was resorted to, and from this cause have proceeded those vast monuments of daring ingenuity which, while they excited the admiration, have baffled the rival attempts of modern architects.

Having thus traced, we hope, perspicuously and satisfactorily, the causes which gave rise to Gothic architecture, and led to its perfection; it will be proper, before discriminating between its several styles, to explain some of its leading principles, and those particulars in which it more especially differs from the better known principles of Greek and Roman architecture.

Of these, the first in importance is the pointed arch, of which

there are three kinds. 1. The simple pointed arch, which is struck from two centres on the line of the impost. 2. The tudor arch, or that which has four centres, of which two are on the line of the impost line, and the other two at any distance. 3. The ogee, which has likewise four centres, two on the impost line, and two on a line with the apex, the segments struck from which are reversed. This form is used only in tracery, or small work, except as a canopy or drip-stone over doors and windows. The pointed arch differs from the semicircular, as employed by the Romans, (besides its form) in having its soffit occupied by mouldings of various projections, instead of being flat, enriched with panels. The cause of this is its great breadth, (having frequently to support a wall and roof), which required the piers to be of corresponding magnitude, to diminish the unpleasing effect of which, the architects surrounded them with slender shafts. The projections of these being carried into the arch caused it to be of the form in question. It is scarcely necessary to add, that these piers are always undiminished. Arising from the general use of the arch is that of the buttress. In Norman work this was avoided by the employment of walls of vast thickness, with very small windows; but when architecture began to assume a lighter character the windows were enlarged, and the thickness of the walls diminished. To compensate for this deficiency, the buttress was employed, at once to resist the press of the arches within, and to prevent the necessity of the walls being of an unwieldy thickness. These are often divided into stages, (each being of less projection than that beneath it) finished by pinnacles, and from the upper part of them spring insulated arches, serving as a protection for the clere-story.

The next thing to be mentioned is the *steeple*, with its component parts and accompaniments. When square topped it is called a tower, which is often crowned with a spire. Slender and lofty towers are called *turrets*, and are commonly attached either to the angles of a large tower (when they frequently contain staircases), or to the angles of a building. They are sometimes surmounted by spires, a beautiful example of which may be seen at Peterborough cathedral, in the turret at the north-west angle. In this exquisite and unique design the turret is square, and decorated at the angle with boltels, which are carried up beyond it, and finished by a triangular pinnacle. The spire in the centre is octagonal, and rectangularly placed within the square, four of its sides thus forming triangles with the angular boltels, which being arched over, form grounds for pinnacles of the same form, which are carried up to about half the height of the spire itself.

The effect is beautiful beyond description, and merits the most attentive examination.

Next in importance are the *windows* of Gothic architecture, but as these differ so widely in the several styles as to form the readiest c iterion for distinguishing them, they will be more properly noticed when we speak of these styles. We shall pursue the same plan with the doors, and other subordinate parts.

It may be proper in this place to say something of the *mouldings* of Gothic architecture. Of these, that which bears the most resemblance to the Roman mouldings is the *ogee*, distinguished by the same name, or that of cyma reversa, in the nomenclature of the Italian school. A moulding used for the same purpose as the cyma recta, and much resembling it, is also found, more frequently perhaps than any other. That which is most peculiar to the style, is the *boltel*, or cylindrical and nearly detached moulding, often answered by a corresponding hollow. In the plate are delineated two forms of exterior drip-stones, (C. *k.* and *l*).

We shall now detail the different styles of Gothic architecture, with the peculiarities of each, and in so doing, follow the arrangement and nomenclature of Mr. Rickman, the only writer who has attempted to give a clear and practical account of this beautiful though neglected style. He distinguishes three variations, which may, without impropriety, be called the *orders* of Gothic architecture; differing, however, from the Greek and Roman orders in this circumstance; that while they are confined to one part of a building, or at most, affect the rest only in regard to strength or delicacy, these extend through every part of the edifice.

The first style, denominated by Mr. Rickman "Early English,"* commenced with the reign of Richard the First, in 1189, and was superseded by the next in 1307, the end of the reign of Edward the First. It is principally distinguished by long narrow windows, and bold ornaments and mouldings. The window being so essential a mark of the style, claims to be considered in the first place.

The Early English window is invariably long and narrow; its head is generally the lancet, or highly pointed arch, but is sometimes formed by a trefoil. In large buildings there are generally found two or more of these combined, with their drip-stones united. Three is

* Although we have adopted the common term of Gothic architecture, the use of the expression, "Early English," is by no means inconsistent; since, though other nations possess similar monuments, it is those of our own country that we are more immediately called upon to illustrate.

the usual number, but sometimes four, five, seven, and in one instance (the east end of Lincoln cathedral) eight are employed. When combined, there is usually a quatrefoil between the heads, and where there are many, the whole is sometimes covered by a segmental pointed drip-stone, to which form the windows are adapted, by the centre one being raised higher than the rest, which are gradually lowered on each side to the extremity. Sometimes, in late buildings, two windows have a pierced quatrefoil between them, and are covered by a simple pointed arch as a drip-stone, thus approaching so nearly the next style as not to be easily distinguished from it: this arrangement may be seen in the nave of Westminster Abbey. In large buildings the windows are frequently decorated with slender shafts, which are usually insulated and connected by bands with the wall. A fine example of this may be seen at the Temple church, London, one of the purest buildings existing of this style.

The circular, rose, or catherine-wheel window is frequently found in large buildings of this style, in which, however, it did not originate, being found in Norman edifices. It appears to have received much attention from the architects of this period, being worked with great care.

The doors of this style are distinguished by their deep recess; columns usually insulated in a deep hollow, and a simple pointed arch, nearly equilateral in the interior mouldings, but in the exterior, from the depth of the door, approaching the semicircle. They are also frequently ornamented by a kind of four-leaved flower placed in a hollow. In large buildings they are often divided by one or more shafts (clustered) in the centre, with one of the circular ornaments above.

To the steeples of this period were added, in many instances, spires, many of which are finely proportioned, and form a very characteristic and elegant finish to the buildings they accompany. They have usually ribs at the angles, which are sometimes crocketted; and in some instances they are still farther enriched with bands of quatrefoils round the spire. The towers are usually guarded at the angles by buttresses, but octagonal turrets are sometimes met with, surmounted by pinnacles of the same plan. In small churches the slope of the spire sometimes projects over the wall of the tower, which is finished by a cornice, and the diagonal sides of the spire (generally octagonal) are sloped down to the angles.

The arches of this style are chiefly distinguished by very numerous, though, for their size, bold mouldings, with hollows of corresponding

depth: the lancet arch is chiefly used, though many are found much more obtuse. The form of the arch, indeed, as Mr. Rickman observes, is by no means a criterion for the distinction of the styles, each form being met with in buildings of each style, except the four-centred.

The piers are distinguished from those of the other styles by being surrounded with bands, which sometimes are confined to the shafts, and sometimes are continued on the pier. The capitals are usually composed by plain bold mouldings, one of which is shewn in the plate, (C *h*) where is also delineated a base of this style, (C *i*). The plan of these piers is usually a circle, surrounded by small shafts, but a beautiful variation (from Salisbury cathedral) is shewn in the plate, (C *d*).

The buttresses of this style are chiefly distinguished by their simplicity, having very few sets-off, and very rarely any ornament in their faces. Frequently, indeed, as at Wells cathedral, (the name of which is very early in this style) they retain the Norman form, of very broad faces with slight projections, with a shaft inserted in the angles, and are continued no higher than the cornice. The flying buttress was not used till late in this style.

The ornamental parts of the style now remain to be considered, which, till near its conclusion, were but sparingly used, and those, for the most part, of a very rude description. In the west fronts of Wells and Peterborough cathedrals may be seen specimens of the taste of the period in these particulars, which are wholly unworthy of imitation; but in the interior of Salisbury are many details, late in the style, which are very elegant, and will bear the most minute examination.

It may be sufficient to mention, that in all the ornamental and minute details during this period, as well as in the more important parts, the boldness and contempt of refinement, which are infallible marks of an early age, are very apparent,* for which reason we shall defer the description of many ornamental details (which, nevertheless, were practised, and with success, in the latter part of this period), till the next style, in which they were brought to perfection.

* We here speak, of course, of pure examples only: there are many, and it is natural that there should be, in which the poverty of mind of the architect is shewn, in a rejection of the grandeur attainable in this style, for a degree of ornament which does not pertain to it, and of which the effect is consequently bad, added to which the infancy of the style, which in its bold and simple feature is not offensive, here displays itself in a manner, and to a degree, which disgusts the eye of taste.

There is, however, one ornament peculiar to this style which it is necessary to notice before we proceed farther. It resembles a low pyramid, of which the sides are pierced in the form of curvilinear triangles, bending inwards, and is usually placed upon a hollow moulding, from which it is sometimes entirely detached except the angles. It has as yet received no regular appellation, on account of its being so unlike any other object as to be with difficulty described, or even delineated, and we believe it must be seen to be accurately comprehended. The only attempt at designation it has received is, the *toothed ornament*. The reason for applying such a name to it we leave for the ingenuity of the reader to discover.

The EARLY ENGLISH style of Gothic architecture may, we think, without impropriety, be compared to the Doric order of the Greeks. Like that, it is the first attempt of a people emerging from barbarism, and like that, it possesses all those qualities which it is natural to expect from such a state of society. Strength and simplicity are its predominating characteristics: ornament, except the most bold and artless, is foreign to its nature, and can never be introduced with propriety. For this reason it may be employed with great advantage in churches, where expense is an object, as a finer effect may be produced by the use of this style than of any other whatever for equal expense. Of the fitness of Gothic architecture for ecclesiastical edifices, we presume it is now needless to say much. The circumstances of its having had its origin in Christian worship, and consequent adaptation to its ceremonies, its fitness for the climate, and its devotional effect upon people in general, seem to point it out as peculiarly appropriate for this service. In exterior effect Gothic architecture is very defective, and never more so than in this style. We have, indeed, scarcely one front which is at all reconcileable to good taste. That of Salisbury cathedral is generally admired, but we can see no reason for the preference. A consciousness of this defect of the style led the architect of that of Peterborough cathedral to make use of a singular expedient. Three ponderous arches supported by triangular piers receive the weight of three gables, and at each lateral extremity is a square turret, containing a staircase, and surmounted by a spire, one of which has been already described. The effect of the composition is grand, but it is not worthy of imitation. A field is thus offered for the exercise of modern invention, which, as this kind of architecture becomes better understood, it is to be hoped will not be neglected: much has been done, but something, we conceive, remains

to do, to render it a worthy and formidable competitor with the long practised and deeply studied architecture of Greece and Rome.

THE DECORATED ENGLISH STYLE.

The style next in order to the Early English is denominated, by Mr. Rickman, *Decorated English*, as possessing a greater degree of delicacy than the former, without the excessive detail of the style which succeeded it. It ceased to be used soon after the death of Edward the Third, which happened in 1307. Its prominent feature is also found in its windows, with which, therefore, we shall commence our description.

The windows of this style are distinguished from those of the last by being larger, and divided into lights by slender upright stones, called mullions.

Of decorated windows there are two descriptions. 1. Where the mullions branch out into geometrical figures, and are all of equal size and shape; and 2. Where they are dispersed through the head in curves of various descriptions, (which is called flowing tracery) and are usually in windows of more than three lights, of different size and shape, the principal mullions forming simple figurés, subdivided by the inferior ones. Sometimes the principal mullions are faced by slender shafts, with bases and capitals. The first description is considered the oldest; the principal example which contains these kind of windows is Exeter cathedral, where they are very large, and nearly all composed of this kind of tracery. The flowing tracery which composes the greater number of windows of this style, will be better understood by reference to the plate than by any description we could give: a small one is delineated at C *c*, of which the form is copied from one at Sleaford church, Lincolnshire: a specimen of the application of the same features to larger windows may be seen in the view, in which the small one forms part of the composition. The architraves are commonly enriched by mouldings, which sometimes assume the form of columns, and the windows in composition frequently reach from pier to pier. The form of the arch is seldom more acute than that described on the equilateral triangle, and it is generally more obtuse. The richness of these windows invariably depends upon their size, the distance between the mullions being nearly the same in all: the largest, however, do not consist of more than nine lights. The

dripstone is in this style improved into an elegant canopy, the form of which is sometimes pedimental, and sometimes an ogee arch: it is decorated with crockets and a finial, and the space inclosed by it and the exterior contour of the arch is sometimes filled with tracery. The great west window of York cathedral, one of the finest in the kingdom, has a triangular one.

The circular window was also brought to perfection in this style. A fine example in form, though not in detail, is now the only remains of the ancient palace of the Bishops of Winchester, in Bankside, Southwark. This is of the geometrical description; one of the finest of flowing tracery is in the south transept of Lincoln cathedral.

The doors of this style are not so distinct as the windows, from those of the former period: double doors are not so frequent, and the shafts are not detached from the mouldings as in the Early English. In small doors there is frequently no column, but the mouldings of the arch are carried down the sides without interruption: there is frequently no base-moulding, but a plain sloped face to receive the architrave. They are surmounted by the same sort of canopies as the windows.

The steeples of this period are distinguished from those of the last in little more than their windows, and a few unimportant details. The north-west spire of Peterborough cathedral, before described, decidedly belongs to it, though the tower beneath is Early English. The tower and spire of Newark church, Lincolnshire, are pointed out by Mr. Rickman as a peculiarly fine example.

The groining of the roofs will be better understood by referring to the plate (C *a*) than by any description that could be given. That which is there introduced is the groining of the nave of York cathedral, the purest existing example of equal richness. Most frequently, however, the merely decorative ribs are omitted, and the rib from pier to pier, with the cross springers, and the longitudinal and transverse ribs only are employed. At the intersection of these, bosses or sculptured ribs are almost invariably placed. The aisle roofs are very rarely enriched with superfluous ribs, but those of Redcliffe church, Bristol, are elegant exceptions.

Of arches little can be said. Of their form, it may be sufficient to observe, that the lancet arch is rarely met with; the tudor never but in one instance, the nave of Winchester cathedral, built, or rather cased, by the celebrated William of Wyckham, and it is here necessarily adopted on account of the form of the Norman arch it was employed to conceal. The mouldings are in general less numerous, and consequently bolder than those of the preceding style. In small

works the ogee arch is frequently found, and decorated with crockets, and a finial. The upper part of one of these is shewn in the plate (C *g*).

The piers of this style are, for the most part, square in their general form, and placed diagonally: two variations of these are shewn in the plate (C *e* and *f*), that marked *e* is from Exeter cathedral, and *f* from the nave of that of York; both pure and beautiful examples. The shafts are sometimes filleted, that is, a square narrow face is continued vertically along its surface, projecting slightly from it. The capitals are frequently enriched with foliage, and the bases, in many instances, consist of reversed ogees, with square faces of various projections, and sometimes other mouldings.

Decorated English buttresses are distinguished from those of the last style which are most applicable to it, only by their greater richness in buildings where decoration is not spared, and consequently, in others they are perhaps the least characteristic parts of the composition. They are, however, usually finished by pinnacles, which are generally distinguishable from those of the former style. The flying buttress is almost invariably used, and is also surmounted by a pinnacle, which usually corresponds with the lower one. The buttresses of the aisles of Exeter cathedral are remarkable for being detached from the wall, the only support they afford to which, is by the arches which connect them with it at the top.

The parapets of this style are sometimes horizontal, and sometimes embattled, each of which are frequently pierced in the form of cinquefoil headed arches, quatrefoils, and triangles. Sunk panels are, however, more common. When plain embattled parapets are employed, the crowning moulding is usually continued horizontally only, the face towards the opening being merely a vertical section.

As many of the ornamental parts of Gothic architecture were brought to perfection during this period, they cannot be better introduced than in this place. Among these the use of crockets is a prominent feature: these are small bunches of foliage running up the side of the *gablet*, afterwards improved into the ogee canopy over doors, windows, and ornamental arches, and finished by a combination of two or more, called a *finial*, which is separated from the rest by a small moulding. They are also used to decorate the angles of pinnacles. The upper part of a canopy of this description is shewn in the plate (C *g*), from which the character of these ornaments will be better understood than by any description. Another peculiarity of Gothic architecture is the *feathering* of windows, screen-work, orna-

mental arches, panels, and sometimes doors. It is called trefoil, quatrefoil, or cinquefoil, according to the number of segments of circles, (which are called *cusps*) of which it is composed: the method of drawing it may be seen by the window (C *c*) in the plate. A very beautiful door thus ornamented, still exists in St. Stephen's chapel, Westminster, now the House of Commons.

Although the grotesque is the prevailing character of the sculpture employed in the decoration of Gothic architecture, many small ornaments are found, particularly in this style, designed with taste and executed with the utmost delicacy. They are copied from the beautiful though humble flowers of the field, and are in many instances local.

We have compared the former style to the Doric of the Greeks, and the present may with little less propriety be likened to the Ionic of the same people. Boldness with simplicity characterize the first; elegance and delicacy the second. In both Greek and Gothic orders, ornament to profusion is allowable; yet in neither does it interfere with the composition, and may be entirely omitted. From this circumstance arises a universal applicability, belonging only to the far-famed "*happy medium*," so often talked of, so seldom attained. In grandeur of composition, simplicity of arrangement, elegance of form, and *perfection* of capability, this style is therefore unrivalled, and may be used with advantage for every purpose of civil architecture. It is, however, perhaps, peculiarly adapted for all churches whose size and situation render them of importance; and in such large buildings where Gothic architecture may be thought desirable, as are of sufficient consequence to allow the architect to think of delicacy in the design of his details.

THE PERPENDICULAR STYLE.

The last of the three grand divisions of Gothic architecture is the *Perpendicular* Style, commencing in the end of the last, and finally overwhelmed by its own superfluity of decoration, and uncompromising minuteness. It was not wholly lost sight of before the reign of James the First, but few buildings were then erected without a mixture of Italian work.

The Perpendicular Style, like the others, is most readily distinguished by its windows, (whence it also derives its appellation:) the

mullions of which, instead of being finished in flowing lines, or geometrical figures, are carried perpendicularly into the head. They are further distinguished by a *transom* or cross mullion, to break the height, under which is usually a feathered arch, and sometimes it is ornamented above by small battlements. The architraves of windows in this style, have seldom shafts or mouldings as in the former, but are worked plain, and frequently with a large hollow. Although these windows do not admit of any great variety in the disposition of the tracery, they are far more numerous than those of either of the other styles; few specimens of which remain, that do not bear marks in their windows, of the rage for alteration which appears to have prevailed at this period.

The *doors* of this style are remarkably varied from those of the preceding ones, by the arch being finished by a horizontal moulding, which is continued down to the springing of the arch, and then shortly returned. This is called a *label:* the space enclosed by it, and the exterior line of the arch is called the *spandrel*, which is commonly filled with a circle ènclosing a quatrefoil or other circular ornament.

The *steeples* of this style are for the most part extremely rich: spires are seldom met with, but lanterns are frequently used. A lantern is a turret placed above a building, and pierced with windows so as to admit light into the space below. This is sometimes placed on the top of a tower, as at Boston, and supported with flying buttresses springing from it, and sometimes constitutes the tower itself, as at York, Peterborough, and Ely cathedrals, where it is placed at the intersection of the cross, and has a very fine effect. The exterior angles are frequently concealed by octagonal turrets containing staircases, but usually strengthened by buttresses either double or diagonal. A most beautiful finish for a steeple is found in that of the church of Newcastle upon Tyne, where a small square tower (each side of which is nearly occupied by a window), surmounted by a spire, is wholly supported by arch buttresses springing from the pinnacles of the great tower. This is copied by Sir Christopher Wren in the church of St. Dunstan's in the East; and, though in workmanship and detail it is far inferior to the original, excels it in the pròportion it bears to the rest of the composition.

Groining, in perpendicular work, assumes a new and more delicate character. A number of small ribs diverging from a centre, are carried up in the form of one side of a pointed arch, and terminated

equi-distantly from that centre by a semi-circle. As they recede from the point, they are divided by smaller ribs or mullions, and those again subdivided, (according to the size of the roof) so as to make all the panels of nearly equal size. These panels are ornamented with feathered arches, &c. in the same manner as the windows, in conformity to which, the whole is designed. The intervals between these semi-circles are filled with tracery of the same description. This kind of roof is called *fan tracery:* it is exquisitely beautiful, and almost the only kind of groining used in this style. Another description of roof must now be mentioned, of very different character; this is the timber roof, of which Westminster-hall presents so magnificent an example. Here the actual timbers of the roof are so arranged, as to form an architectural combination of great beauty: a wooden arch springs from each side of the building, supporting a pointed central one, finished downwards with pendants: the rest of the framing is filled with pierced panelling. This kind of roof is not found in churches, but it seems well adapted for large halls, for public business, or any place intended for the occasional reception of large meetings.

The *arch* in late perpendicular work is generally low in proportion to its breadth, and described from four centres; this is called the Tudor arch, from its having been principally in use under the reign of two princes of that family. Besides this distinction in the form of the arch, there is an important one in the arrangement of the mouldings, which are carried down the architrave without being broken by a capital, and sometimes there is one shaft with the capital and the others without.

The *piers* are remarkable for their depth in proportion to their width: frequently there is a flat face of considerable breadth in the inside of the arch, and a shaft in front running up to support the groining. The capitals, when there are any, are generally composed with plain mouldings, but there is sometimes a four-leaved square flower, placed in the hollow.

The *buttresses* and *pinnacles* contain little remarkable, and are only distinguished from those of the last style by their extraneous ornaments, if they have any: the buttresses are sometimes panelled, and in some very late specimens the pinnacles are in the form of domes, of which the contour is an ogee arch.

The *parapets* of this style are generally embattled and pierced; they are worked with great delicacy in the form of quatrefoil circles, &c.

The *ornament* of the Perpendicular Style is well characterised by the name, many buildings being as Mr. Rickman observes, nothing but a series of vertical panelling ; " for example," says he " King's-college chapel is all panel, except the floor; for the doors and windows are nothing but pierced panels, included in the general design ; and the very roof is a series of them in different shapes."* Monotony is inseparable from such an arrangement, grandeur is incompatible with it; and the appearance of it is a certain prognostic of decline in whatever is marked by its introduction. A beautiful small ornament peculiar to this style is the Tudor flower, which is a series of square flowers, placed diagonally and frequently attached, connected at the bottom by semi-circles: the lower interstices are filled with some smaller ornament. This is principally employed as a finish to cornices in ornamental work.

With whatever justice the preceding styles have been assimilated with the Doric and Ionic orders of Grecian architecture, the comparison does not hold between the present and the Corinthian. The former is a necessary gradation in the art, and is applicable to compositions of any size. The latter is not necessary, and is unpleasing except in small works. Almost every peculiarity in this style indicates approaching dissolution—the change from the graceful forms of the decorated windows to inelegant, artless, straight lines; the alteration in the form of the arch ; thus deviating from one of the leading principles of Gothic architecture; and above all, that inordinate passion for ornament and minutiæ, which, like excessive refinement in other matters, is a certain mark of the decay of true taste. These circumstances, however, which render the perpendicular style so objectionable for large buildings, make it peculiarly appropriate for

* " Attempt to discriminate the Styles of English Architecture," by J. Rickman, architect. We take this opportunity of expressing our obligations to this interesting and valuable work, which is the only treatise of the kind worth mentioning, and certainly the most useful book existing, on the subject of Gothic architecture. Instead of entertaining the reader with fanciful theories of the *pointed arch*, its invention, and whence it was derived, or disputing concerning which of the European nations first adopted it, Mr. Rickman takes Gothic architecture as it stands, on English ground, and explains, as far as the limits of his work permit, the peculiarities of the various styles. From this work therefore, we have principally derived this short sketch, and if we have too closely copied it, it is, because to its author belongs the merit of having made the first, and as yet the only attempt to rescue this beautiful style from the state of a mere dead language, fit for study (if it were allowed to rank even *so* high) rather than for use.

small and confined parts of a building, such as chapels and domestic apartments, where Gothic architecture is preferred. For the latter purpose, we fear indeed it is ill adapted in any shape; all its peculiarities seem to point at magnificence and imposing effect (with which magnitude is inseparably connected,) as their ultimate objects and the most proper field for their display: and with these qualities, it is well known, domestic comfort has little in common. The confined space in which the latter can alone be enjoyed, is ill reconcileable with the interminable vistas and lofty proportions, by many considered as the perfection of the former. It is, however, not only proper but necessary in some cases to employ the Gothic in the decoration of apartments, and where this happens, this style is decidedly preferable.

It has been truly observed by an ingenious writer on the subject of English architecture, that it can in no case be advantageously blended with the Grecian, differing, as it does, so essentially in its component parts; that this, however, is the fact, may be readily seen by reference to the following comparative view, for which we are indebted to the same able author.

Grecian.	*English.*
The general running lines are horizontal.	The general running lines are perpendicular.
Arches not necessary.	Arches a really fundamental principle, and no pure English building or ornament can be composed without them.
An entablature absolutely necessary, consisting always of two, and mostly of three distinct parts, having a close relation to, and its character and ornaments determined by the columns.	No such thing as an entablature composed of parts, and what is called a cornice, bears no real relation to the shafts which may be in the same building.
The columns can support nothing but an entablature, and no arch can spring directly from a column.	The shafts can only support an arched moulding, and in no case a horizontal line.
A flat column may be called a	Nothing analagous to a pilaster;

Grecian.	*English.*
pilaster, which can be used as a column.	every flat ornamented projecting surface, is either a series of pannels, or a buttress.
The arch must spring from a horizontal line.	No horizontal line necessary, and never any but the small cap of a shaft.
Columns the supporters of the entablature.	Shaft bears nothing, and is only ornamental, and the round pier still a pier.
No projections like buttresses, and all projections stopped by horizontal lines.	Buttresses essential parts, and stop all horizontal lines.
Arrangement of pediment fixed.	Pediment only an ornamented end wall, and may be of almost any pitch.
Openings limited by the proportions of the column.	Openings almost unlimited.
Regularity of composition on each side of a centre necessary.	Regularity of composition seldom found, and variety of ornament universal.
Cannot form good steeples, because they must resemble unconnected buildings piled on each other.	From its perpendicular lines, may be carried to any practicable height, with almost increasing beauty.

We have now gone through the two first parts of our design, as stated at the commencement: we are now, in conclusion, to offer a few remarks on domestic architecture, in fulfilment of the third.

With respect to the situation of a house, where choice is allowed; it is obvious, that the most desirable must be that, which combines the advantages of pure air and protection from cold winds, with a plentiful supply of water, convenient access, &c. As these observations, however, must present themselves to every one, we shall not here dwell upon them, but proceed to consider those essential parts of a house, *rooms*. And first, their effect upon the exterior figure of a house.

The form which gives the largest area with the least circumference is evidently a circle; but this figure when divided into apartments is very inconvenient, from the numerous acute angles and broken curves which must necessarily compose them. Nearly the same objections apply to the triangle, which has the farther disadvantage of occupying a smaller area with respect to its circumference than any other figure.

Rectangular forms, therefore, are best adapted for houses in general; since within them, the divisions of apartments may be made with the greatest regularity and least waste. As rectangles most readily divide into rectangles, this is also the figure which may be employed to the greatest advantage in the rooms themselves. For proportion, a square to a square and a half is used, longer than which partakes too much of the gallery form. The usual rule for the height of a room is, if it be oblong, to make it as high as broad, and if square from four-fifths to five-sixths of the side is a good proportion. With regard to health however, no room should be less than ten feet in height. It is obvious, that in a floor where there are many rooms they must be of various sizes, and to regulate the heights of all of them by architectural rules, would be productive of much inconvenience. As therefore, the apparent height of a flat ceiled room is greater than that of a coved one of equal altitude, it is usual in these cases to make the larger rooms with flat ceilings, and the smaller with coved ones, or domes. Apartments of state or unusual size may occupy two stories.

With regard to the decoration of ceilings a great diversity of taste exists. At one period no ceiling was thought to be sufficiently ornamented unless it was covered with paintings, chiefly representing allegorical subjects. This taste was carried to a great excess, and was the subject of much ridicule. Of late years, ornament of any description has been thought superfluous, and the ceiling has been usually left completely bare. This is, however, now giving way to the geometrical decorations prevalent during the middle and latter part of the last century, which certainly give an enriched effect to a room, and possess this advantage over every other method of decoration, that they are capable of any degree of simplicity or richness both in form and detail, according to the size of the apartment, or quantity of decoration used in it. For rooms which are small, and of which the ceiling is consequently near the eye, these ornaments should be delicately worked, but in those of larger size they require to be bolder. The angles formed by the ceiling and walls are concealed by cor-

nices, the enrichment of which will of course depend upon the delicacy or simplicity observed in the embellishment of the room.

DOORS.

THE usual proportion for doors is rather more than a double square, unless they are of considerable size: in ordinary houses they should be in the inside from two feet nine to three feet six in breadth, and nearly or quite seven feet in height: and the entrance doors from three feet six to six feet broad, and at least eight feet high. In very large houses and public edifices the dimensions must of course exceed these, but no door should be more than twelve feet wide. Folding doors are frequently employed to connect rooms, which will of course considerably reduce the proportionate altitude.

The doors of apartments should be in the middle of the room, and where there is a suite, all the doors should be of the same size, and exactly opposite each other. They should never be placed near the fire-place; nor, in a bed-room, by the side of the bed; except such as communicate with a dressing-room, or other convenience peculiar to the room.

The usual manner of ornamenting doors is, if they are in the interior, to surround them with an architrave, which is sometimes surmounted with a frieze and cornice; and exterior doors have frequently an entablature over them, which is supported either by consoles, pilasters, or attached columns.

WINDOWS.

IT is obvious, that in arranging the windows of an apartment, it will first be necessary to decide on the quantity of light required to be admitted. Sir William Chambers observes, that in the course of his own practice he has generally added the depth and height of the rooms on the principal floor together, and taken one-eighth part thereof for the width of the window.

The height of the aperture in the principal floor should not much exceed double the width. In the other stories they are necessarily lower in proportion, the width continuing the same. The windows in modern houses are frequently brought down to the floor, in imitation of the French; but where this is not the case, the sills should be from two feet nine to three feet from the floor.

The windows of the principal floor are generally the most enriched, and the usual manner of decorating them is, by an architrave surrounding them with a frieze and cornice, and sometimes a pediment. When they are required more simple the frieze and cornice are omitted. In a front the pediments are, for the sake of variety, often made triangular, and curved alternately, as in the Banqueting-house at Whitehall.

When windows are required very broad in proportion to their height, the *Venetian* window is frequently employed, which consists of three contiguous apertures, the centre one being arched. The usual mode of executing this is, by dividing the apertures by columns, and placing corresponding ones at the extremities of the opening: the side apertures are covered by an entablature, and the centre by a semicircular architrave, of which the entablatures form the imposts.

CHIMNEY-PIECES.

The necessary remarks on chimneys, as a part of *building*, will be more properly introduced in another place: we have here only to consider them as parts of a room and its decoration.

With respect to the situation of chimney-pieces, we have already mentioned that they should be sufficiently removed from the door: Sir William Chambers farther advises, that it should be "so situated as to be immediately seen by those who enter, that they may not have the persons already in the room, who are generally seated about the fire, to search for." Whether the worthy knight had experienced personal inconvenience from a mal-disposition in this respect, we cannot tell, but do not conceive it to be an evil of the first magnitude.

The standard proportion of the chimney-piece is a square; in larger rooms somewhat lower, and in smaller, a little higher: its size will of course depend on the quantity of space to be heated, but the width of the aperture should not be less than three feet, nor more than five feet six. When the size of the apartment is considerable, it is better to make two fire-places.

In the decoration of chimney-pieces the utmost wildness of fancy has been indulged, but it is certainly proper to regulate their ornaments by the style of the building to which they belong. Those in which the Roman style predominates are designed much in the same manner as the windows, except where magnificence is attempted, in which case caryatides, termini, &c. are employed.

STAIRS.

"Staircases," says Palladio, "will be commendable if they are clear, ample, and commodious to ascend, inviting, as it were, people to go up: they will be clear if they have a bright and equally diffused light: they will be sufficiently ample if they do not seem scanty and narrow to the size and quality of the fabric, but they should never be less than four feet in width, that two persons may pass each other: they will be convenient with respect to the whole building if the arches under them can be used for domestic purposes; and, with respect to persons, if their ascent is not too steep and difficult, to avoid which, the steps should be twice as broad as high."

Steps should not exceed six inches, nor be less than four inches in height: their surfaces are sometimes inclined planes, for greater ease in ascending. The ancients were accustomed to make them of an odd number, that they might arrive at the top with the same foot that they began the ascent with: this arose from a superstitious idea of devotion in entering their temples. Palladio directs that the number of steps should not exceed thirteen before arriving at a resting-place.

Staircases are either rectilinear or curvilinear in their forms: the former are most usual in dwelling-houses, as being more simple, and in general executed with less waste of material; but the latter (which may be either circular or elliptical) admit of greater beauty, if large, and greater conveniency, if small. Small staircases of this description are generally circular, and have a column (called a newel) in the middle: they are constructed with great simplicity, (the newel being composed of the ends of the steps, while the other rests in the wall), and are found in all our country churches. When ornament is studied, the steps may be made curved, which has a very pleasing effect.

In large designs, however, the elliptical form is generally preferred, and is capable of very grand effects, which Sir William Chambers has sufficiently shewn in one of the staircases at Somerset-place, (that belonging to the Royal Society, and Society of Antiquaries), which, without any superfluous decoration, is a design of uncommon magnificence, and excelled by few of the kind. The newel being of a very unpleasing form in this kind of staircase, is an objection to its use where it is of a small size.

Those staircases which are open in the centre are generally lighted from the top, but where this is impracticable, the light is admitted by windows in the most advantageous position the situation will allow.

A GLOSSARY OF ARCHITECTURAL TERMS.

A.

Abacus, a member placed above the capital to receive the entablature.

Abutment, a pier upon which the extremity of an arch rests.

Acroteria, small pedestals placed on the apex and two sides of a pediment. They sometimes support statues.

Amphiprostyle, an order of temples among the Greeks, having columns in the back as well as front.

Ancones, the carved key-stones of arches.

Annulet, a small square moulding commonly used to connect the others.

Antæ, (*in Grecian architecture*) small projections from the wall to receive the entablature from the columns of a portico, and having bases and capitals different from the columns.

Apophyge, the curve connecting the upper fillet of the base, or under one of the capital, with the cylindrical part of the shaft.

Aræostyle, a manner of intercolumniation, in which the columns are distant from each other about four diameters.

Arch, an arrangement of solid materials in such a manner, as by their mutual pressure to sustain superincumbent weights.

Arch-buttress, or *Flying-buttress*, (*in Gothic architecture*) an arch springing from a buttress or pier and abutting against a wall.

Architrave, the undermost principal division of an entablature.

Astragal, a small moulding, semicircular in profile.

Auriel, or *Oriel, window*, (*in Gothic architecture*), a window projecting outwards for private conference; whence its appellation.

B.

Baluster, a small pillar supporting a rail; commonly used as a parapet.

Balustrade, a number of balusters connected by the rail.

Band, a square member in a profile.

Base, the lower division of a column. In the Greek Doric there is no base.

Battlement. See *Parapet*.

Bay, (*in Gothic architecture*), an opening between piers, beams, or mullions.

Bay Window. See *Auriel*.

Bed-mouldings, the mouldings below the corona in a cornice.

Billet-moulding, (*in Gothic architecture*), a cylindrical moulding, discontinued and renewed at regular intervals.

Boltel, (*in Gothic architecture*), slender shafts, whether arranged round a pier, or attached to doors, windows, &c. The term is also used for any cylindrical moulding.

Boss, (*in Gothic architecture*), a sculptured protuberance at the interjunction of the ribs in a vaulted roof.

Boultin, a name for the echinus.

Broach, (*in Gothic architecture*), a spire, or polygonal pyramid, whether of stone or timber.

Bracket, (*in Gothic architecture*), a projection to sustain a statue, or other ornament; and sometimes supporting the ribs of a roof.

Buttress, (*in Gothic architecture*), a projection on the exterior of a wall, to strengthen the piers and resist the pressure of the arches within.

C.

Cabling, cylindrical pieces let into the lower part of the flutes of columns.

Caisson, a name for sunk panels of geometrical forms.

Canopy, (*in Gothic architecture*), the ornamented dripstone of an arch. It is usually of the ogee form.

Canted, (*in Gothic architecture*), any part of a building having its angles cut off, is said to be canted.

Capital, the upper division of a column, or pillar.

Cartouch, the square blocks under the eaves of a house.

Cavetto, one of the regular mouldings of Roman architecture, hollowed in the form of a quadrant of a circle.

Chamfer, (*in Gothic architecture*), an arch, or jamb of a door, canted.

Champ, (*in Gothic architecture*), a flat surface in a wall or pier, as distinguished from a moulding, shaft, or panel.

Cheveron. See *Zigzag*.

Cincture, a ring or fillet surrounding the top and bottom of a shaft, with which it is connected by the *Apophyge*.

Cinque-foil, (*in Gothic architecture*), an ornamental figure with five leaves or points.

Coin. See *Quoin*.

Column. According to the best method of describing it, a column is a frustrum of a very elongated parabola, and circular in its plan; it consists (*in Greek and Roman architecture*) of three parts, *viz*. the base, the shaft, and the capital.

Conge, a moulding consisting of a simple curve, whether bending outwards, as the ovolo, or swelling conge, or inwards, as the cavetto, or hollow conge.

Console. See *Ancones*.

Cope, Coping, (*in Gothic architecture*) the stone covering the top of a wall or parapet.

Corbel, (*in Gothic architecture*), a kind of bracket. The term is generally used for a continued series of brackets on the exterior of a building supporting a projecting battlement, which is called a *Corbel table*.

Cornice, a projecting member which constitutes the upper finishing of a wall or entablature.

Corona, the upper member of a cornice (*in Greek and Roman architecture*).

Crenelle, (*in Gothic architecture*), the opening of an embattled parapet.

Crest, (*in Gothic architecture*), a crowning ornament of leaves running on the top of a screen, or other ornamental work.

Crocket, (*in Gothic architecture*), an ornament of leaves running up the sides of a gable, or ornamented canopy.

Cusp, (*in Gothic architecture*), a name for the segments of circles forming the trefoil, quatrefoil, &c.

Cyma cymatium. The cyma is of two kinds: the cyma recta, a moulding hollowed at the top and swelling beneath, generally called *cymatium;* and the cyma reversa, or ogee, which is swelled above and hollowed beneath.

D.

Dentils, small square projections used in the cornices of several of the Roman orders.

Diapered, (*in Gothic architecture*), a panel, or other flat surface, sculptured with flowers, is said to be diapered.

Diastyle, a manner of intercolumniation in which the columns are three diameters apart.

Die, the body of a pedestal.

Dome, a concave ceiling, commonly hemispherical.

Dormant or *Dormer window*, (*in Gothic architecture*), a window set upon the slope of a roof or spire.

Drip, (*in Gothic architecture*), a moulding much resembling the cymatium of Roman architecture, and used for the same purpose as a canopy over the arch of a door or window.

E.

Echinus a moulding, in the Roman orders, consisting of the quadrant of a circle turned outwards: in the Greek it is composed of one of the conic sections.

Embrasure, (*in Gothic architecture*), the same as *Crenelle*, which see.

Encarpus, the festoons on a frieze. See *Festoon*.

Entablature, the horizontal part of an order, supported by the columns.

Entail, (*in Gothic architecture*), delicate carving.

Entasis, the swelling of a column.

Epistylium. See *Architrave*.

Eustyle, the manner of intercolumniation, in which the columns are distant two diameters and a quarter.

F.

Fane, *Phane*, *Vane*, (*in Gothic architecture*), a plate of metal usually cut into some fantastic form, and turning on a pivot to determine the course of the wind.

Fascia, a band or fillet. This term is usually employed to denote the flat members into which the architrave is divided.

Fastigium. See *Pediment*.

Festoon, a carved ornament resembling a wreath, attached at both ends and falling in the middle.

Fillet. See *Annulet*.

Finial, (*in Gothic architecture*), the ornament consisting usually of four crockets, which is employed to finish a pinnacle, gable, or canopy.

Flutings, vertical channels on the shafts of columns.

Frieze, the member of an entablature between the architrave and cornice.

Fust, the shaft of a column.

G.

Gable, (*in Gothic architecture*), the triangularly-headed wall which covers the end of a roof.

Gable window, (*in Gothic architecture*), a window in a gable. These are generally the largest windows in the composition, frequently occupying nearly the whole space of the wall.

Gablet, (*in Gothic architecture*), a little gable. See *Canopy*.

Garland, (*in Gothic architecture*), an ornamental band surrounding the top of a tower or spire.

Glyphs, the channels in the triglyphs of the Doric frieze.

Gola. See *Ogee*.

Gorge. See *Cavetto*.

Groin, (*in Gothic architecture*), the diagonal line formed by the intersection of two vaults in a roof.

Guttæ, small cones representing drops placed in the soffit of the mutules, and under the triglyphs in the Doric entablature.

H.

Hood-mould, (*in Gothic architecture*). See *Drip*.

Hyperthyron, the lintel of a door-way.

Hypotrachelion, the neck of a capital.

I.

Jamb, the side-piece of any opening in a wall.

Impost, any combination of mouldings serving as the capital or cornice of a pier, upon which either extremity of an arch rests.

Intercolumniation, the distance between two columns.

K.

Key-stone, the centre or highest stone in an arch: it is frequently larger than the rest, and ornamented with sculpture.

L.

Label, (*in Gothic architecture*), a name for the drip or hood-moulding of an arch when it is returned square.

Lantern, (*in Gothic architecture*), a turret or tower placed above a building, pierced either with windows to admit light, or holes to let out steam.

Larmier. See *Corona*.

Lintel, the horizontal piece which covers the opening of a door or window.

Lis. See *Fillet*.

Loop, (*in Gothic architecture*), a small narrow window.

Louvre, (*in Gothic architecture*). See *Lantern*.

M.

Machicolations, (*in Gothic architecture*), small openings in an embattled parapet, for the discharge of missile weapons upon the assailants. Frequently these openings are underneath the parapet, in which case the whole is brought forward and supported by corbels.

Metope, the space between two triglyphs in the Doric frieze. It is frequently decorated with sculpture.

Mezzanino, a low story between two floors.

Minute, the sixtieth part of the diameter of a column.

Modillion, a projection under the corona of the richer orders resembling a bracket.

Module, the semi-diameter of a column at the foot of a shaft. Strictly speaking, this definition is correct only when applied to

the Doric order; but expediency has over-ruled this nicety, and it is commonly used indiscriminately for all.

Mouldings, the smaller parts of architecture, whether Roman or Gothic, which are shaped in regular forms. They are so called from being worked with a *mould*.

Mullion, (*in Gothic architecture*), the frame-work of a window.

Mutule, those projections in the Doric cornice supposed to represent the ends of rafters.

N.

Neck-mould, (*in Gothic architecture*), the moulding separating the capital from the shaft, or that under the finial of a pinnacle or canopy.

Newel, in a circular staircase, the centre round which the steps ascend.

Niche, a cavity in a wall to receive a statue or other ornament. In Roman architecture niches are generally unornamented, but in Gothic they are, for the most part, highly enriched.

O.

Obelisk, a frustrum of a slender pyramid, usually placed on a pedestal.

Ogee. See *Cyma reversa*. This term is usually employed when the moulding occurs in Gothic architecture.

Orlo, the plinth of a column or pedestal.

Ovolo. See *Echinus*.

P.

Panel, a compartment enclosed by mouldings.

Parapet, a low wall round the roof of a building. In Gothic architecture it is frequently divided by openings, or crenelles, when it is called *embattled*.

Parastatæ, insulated pilasters.

Pedestal, a low basement under a column or wall.

Pediment, the triangular crowning ornament of the front of a building, door, &c. When used merely as an ornament, it is sometimes in the form of the segment of a circle.

Pend, (*in Gothic architecture*), a vaulted roof without groining.

Pendant, (*in Gothic architecture*), a hanging ornament in highly enriched vaulted roofs.

Piazza, a square space enclosed by buildings.

Pier, the solid part of a wall between windows or other openings: the support of an arch; the post of a gate.

Pilaster, a pillar of a rectangular plan.

Pillar, any supporting pier.

Pinnacle, (*in Gothic architecture*), a small spire.

Planceer. See *Soffit*.

Platband, a square member of slight projection.

Plinth, the square solid under the base of a column, pedestal, or wall.

Portico, an entablature supported by columns, and surmounted by a pediment.

Profile, the contour of the parts composing an order.

Pycnostyle, a manner of intercolumniation of one diameter and a half.

Pyramid, a solid figure, having its base triangular, square, or polygonal, and terminating in a point at top.

Q.

Quatrefoil, (*in Gothic architecture*), an ornament in tracery, consisting of four segments of circles, or cusps, within a circle.

Quoins, the corners of a building.

R.

Reglet. See *Annulet*.

Regula. See *Annulet*.

Reticulated work, a kind of wall in which the stones are square, and placed lozenge-wise.

Rustic, a manner of masonry in which the stones are indented at their angles; also stones left rough.

S.

Scapus. See *Shaft*.

Scotia, the name of a hollowed moulding used only between two tori in the base of a column.

Severy, (*in Gothic architecture*), a separate portion of a building.

Shaft, the part of a column between the base and capital. In Gothic architecture, the small slender columns surrounding the pier.

Shank, a name for the flat space between the channels in the Doric triglyph.

Socle. See *Plinth*.

Soffit, the under side of any member or arch, whether in Roman or Gothic architecture.

Spandrel, (*in Gothic architecture*), the triangular space enclosed by one side of an arch, and two lines at right angles to each other, one horizontal, and on a level with the apex of the arch, the other perpendicular, and a continuation of the line of the jamb.

Spire, (*in Gothic architecture*), a slender pyramid of a polygonal plan.

Steeple, (*in Gothic architecture*), a bell tower.

Stylobata. See *Pedestal*.

Systile, an intercolumniation of two diameters.

T.

Table, (*in Gothic architecture*), any surface, or flat member.

Tænia, the term for the fillet separating the frieze from the architrave in the Doric order.

Talon, a French term, either for the astragal or cyma reversa.

Terminus, a kind of pedestal smaller at bottom than at top, usually crowned by a bust.

Torus, a large moulding, semicircular in profile, used in bases.

Trabeation. See *Entablature*.

Tracery, (*in Gothic architecture*), a term for the intersection, in various forms, of the mullions in the head of a window or screen.

Transom, (*in Gothic architecture*), a cross mullion in a window.

Trefoil, (*in Gothic architecture*), an ornament, consisting of three cusps in a circle.

Triglyph, the ornament in the Doric frieze, supposed to represent the end of beams.

Trochilus. See *Scotia*.

Tympanum, the space within a pediment: it is sometimes adorned with sculpture.

V.

Vase, a name for the bell, or naked form of the Corinthian capital, on which the leaves are disposed.

Vault, an arched roof. When more than a semicircle they are called *surmounted*, and when less, *surbased* vaults.

Vice, (*in Gothic architecture*), a spiral staircase.

Volute, the scroll which distinguishes the Ionic capital

Z.

Zigzag, (*in Gothic architecture*), an ornament so called from its resemblance to the letter.

Zocle, or *Zoccolo*. See *Socle*

Zoophorus. See *Frieze*.

THE BRICKLAYER'S COMPLETE GUIDE.

BRICKLAYING.

Of the various mechanical arts on which architecture is dependant, the art of bricklaying is one of the most essential, and as it generally takes precedence of the rest in constructing an edifice, it may not be improper to introduce it here, before entering upon each respectively.

The business of a bricklayer, in London, includes tiling, walling, chimney work, and paving with bricks and tiles. In the country it also includes the mason's and plasterer's business. The materials used by bricklayers are, bricks, tiles, mortar, laths, nails, and tile-pins. Their tools are, a brick-trowel, to take up mortar; a brick-axe, to cut bricks to a determined shape: a saw, for sawing bricks; a rub-stone, on which to rub them; also a square, wherewith to lay the bed or bottom, and face or surface of the brick, to see whether they be at right angles; a bevel, which is employed to cut the under sides of bricks to the angles required; a small trannel of iron, wherewith to mark the bricks; a float-stone, to rub a moulding of brick to the pattern described; a banker, to cut the bricks on; line-pins, to lay their rows or courses by; plumb-rule and level, to regulate the parallelism of their work; square, to set off right angles; ten foot rod, wherewith to take dimensions; jointer, which is employed to take the long joints; rammer, wherewith to beat the foundation; crow and pick-axe, wherewith to dig through the walls.

Brickmaking.

Bricks are a kind of artificial stone, made by tempering clay to a proper consistence, and forcing it into a mould to give it the due shape, which is that of a rectangular prism, ten inches in length, and three inches in breadth. Bricks thus formed are dried in the sun and then burnt in stacks or clamps, or in a kiln; in which operation they are reduced to nine inches long, four inches and a half broad, and two inches and a half thick, this, however, varies according to the quality of the clay, and the quantity of burning.

There are several kinds of bricks, as marls, stocks, and place bricks. The principal difference consists in the care in tempering the clay, and diffusing the heat through the whole in burning. The finest kinds of marls are called firsts, and are selected for arches over doors and windows, for which they are rubbed to their proper forms; there are also seconds, which are used for fronting.

The best marls are superior to stock bricks in colour, which is a pale yellow, and consequently more chaste for the front of a house, red being too glaring, particularly for country houses, where it very ill accords with the surrounding scenery.

There are also grey stocks, which are of an inferior kind.

What are left of the clamp after the marls are selected, are called place bricks, packings or sandal bricks; these are of a very inferior quality, not uniformly burnt, and are of a redder colour

Burrs, or, as they are sometimes called, clinkers, are such as are so much over burnt as to vitrify and run two or three together. The best red brick, made out of the neighbourhood of London, are used for rubbers. Some very good are made at Hedgerly, near Windsor, and are called Windsor bricks; they are very hard, of a fine red colour, and preferred as fire bricks, for which purpose they are much used. Their thickness is only one inch and a half, but their length and breadth are the same as the stock brick. All bricks are sold by the thousand, and each brick, according to Act of Parliament, must measure eight inches and a half long, four inches wide, and two inches and a half thick.

There is a kind of brick imported from Holland, called Dutch clinkers, very hard, and of a light yellow colour, used much for paving. They measure six inches long, and three inches broad; the best mode of laying them is herring-bone ways.

Paving tiles are a long flat kind of brick, used for laying the floor of dairies, cheese-houses, &c. their size is about nine inches long, four inches and a half broad, and one inch and a half thick.

The different sorts of tiles for covering houses, are pan tiles, which

are thirteen inches long, and eight inches broad, and about half an inch thick; their transverse section somewhat resembles the letter ∽, being two portions of cylindric surfaces on both sides. The part which is of the greatest radius serves as a channel for conducting the rain, whilst the lesser overlaps the edge of the adjoining tile. In the formation of the pantile, a nob is made to project from the surface of the upper end, which serves to hang it on the lath. Laths for tiling are about three-fourths of an inch thick, and one inch and a quarter broad, and most commonly made of deal. The other sorts of tiles are plain tiles, hip tiles, and ridge tiles.

The earth proper for making bricks, is a clayey loam, neither abounding too much with sand, which renders them brittle, nor with too large a portion of argillaceous matter, which causes them to shrink and crack in drying.

The manufacture of bricks has of late years become an object of revenue, and as such, entitled to some consideration; it is, besides, of the utmost importance to the community, inasmuch as the value and comfort of our dwellings must depend in a great measure on the quality of the materials with which they are constructed, and bricks form no inconsiderable part of them. The best general account we have seen of this art, is given in "Malcolm's Compendium of Modern Husbandry," from which we furnish the following extract:—

"The moulds used in making every sort of brick for building purposes, are ten inches in length, and five in breadth; and the bricks when burned, usually measure nine inches in length, and four and one-half in breadth, so that the clamp shrinks about one inch in ten. But the degree of contraction, (as we have before seen) which clay undergoes in being burned, does not absolutely depend upon the purity of the clay; for some clay imbibes more moisture than others; if that which imbibes the most is not exposed a much longer time to the frost to divide and separate its particles, and to the heat of the sun to exhale its moisture, than that which imbibes less and is a shorter time exposed; it follows, that while the one will be reduced one inch, the other may lose two or more. Again, the heat of the kiln or clamp, and the situation of the bricks as to heat, will vary the diminution of the subject to be burnt. It is of consequence, therefore, in the making of sound hard bricks, that the clay should be dug two or three years before it is used, in order that it may be pulverized; and the oftener it is turned and incorporated, the better will be the bricks. The earth should have sufficient time to mellow and ferment, which will render it more apt and fit to temper; and this operation of

treading and tempering ought to be performed more than doubly what is usual; because the goodness of the bricks wholly depends upon the well-performance of its first preparation, since the earth in itself, before it is wrought, is generally brittle, full of extraneous matter, which requires to be removed, and as it were without unity or stability; but by adding small quantities of water by degrees to it, and working and incorporating it together, the several parts of it are opened, and by being thus exposed to the atmosphere, a tough gluey substance is formed, which, without such tempering, treading, and beating, could not have been produced.

Bricks thus tempered, become solid, smooth, hard, and durable, and one brick, thus made, takes up nearly as much earth as a brick and a half made in the common way, which are light, full of cracks, and spongy, owing to the want of due working and management; to confirm this observation, we shall give the following experiment, made by M. Gallon. He took a certain quantity of the earth prepared for the making of bricks, he let it remain for seven hours, then caused it to be moistened and beaten during the space of thirty minutes; the next morning the same operation was repeated, and the earth was beaten for thirty minutes; in the afternoon it was again beaten for fifteen minutes. Thus, this earth had only been worked for an hour and a quarter longer than usual, but at three different times. The material had acquired a greater density by this preparation; for a brick made with this earth weighed five pounds eleven ounces, while another brick made in the same mould, of the earth that had not received this preparation, weighed only five pounds seven ounces. Then having dried these bricks in the air during the space of thirteen days, and having burnt them with others, without any particular precautions, they were examined when taken from the kiln, and it was found that the bricks made of the earth which had been the most worked still weighed four ounces more than the others, each having lost five ounces by the evaporation of the moisture. But their strength was very different, for, on placing them with the centre on a sharp edge, and loading the two ends, the bricks formed with the well tempered earth were broken with a weight at each end, of 65 pounds, or 130 pounds in all, while the others were broken with 35 pounds at each end, or 70 pounds in the whole. A mixture of ashes, which is now uniformly practised about London, and light sandy earth, which is usually practised in the country, facilitates the work, and serves also to save coals or the wood in burning them.

The excellence of bricks then consists chiefly in the first and last

operation; for bricks made of good earth, and well tempered, become solid and ponderous, and therefore will take up a longer time in drying and burning than our common bricks seem to require. It is also to be observed, that the well drying of bricks, before they are burned, prevents cracking and crumbling in their burning; for when the bricks are too wet, the parts are prevented from adhering together The best way of ordering the fire is, to make it gentle at first, and increase it by degrees, as the bricks grow harder.

The common computation is, that every acre of land will yield one million of bricks in every foot in depth, including ashes, which are usually mixed with it. In general our fields are shallow, with a bottom of gravel, yet we think they will average nearly five feet, though we believe we have none that will run twelve or more feet, as about Kingsland; at least such is Mr. Malcolm's information on this subject.

Bricks are made by the thousand, as the most satisfactory mode between master and man, and a handy man could mould in one day, from five in the morning until eight at night, about 5000. To assist him in the preparation of the soil, &c. from the heap (which is usually dug after the season for brickmaking is over and laid up) there is generally a gang consisting of six persons; one man tempers and prepares the soil, which is done with a hoe, made long, in the shape of a mattock, a shovel, scoop, a thick plank or board, and a cuckhold; with the hoe he pulls down the soil from the great heap, which is chopped backwards with the shovel, to turn it as often as may be necessary, to mix and thoroughly incorporate the ashes and soil together, because it is to be understood, that at the time the soil is dug out, and made into this heap, a layer of coal ashes is alternately placed between a layer of soil, as often and in such quantities in each layer as the quality of the soil and other circumstances may make necessary. The scoop is used to throw water over this portion that is pulled down with the hoe, in order that it may become more and more in a tempering state, more soft and ductile; and with the board he kneads it together, over which a certain quantity of sand is thrown, and it is then covered with pieces of sacking or matting to keep the sun and air from it. A boy scoops or cuts off a slice with an instrument or shovel having a short handle, and the blade of it made concave, called a cuckhold; this he brings on his arms to the moulding-table, which is placed under a moveable shed, upon which another boy rolls out a lump somewhat bigger than will fit the mould, the table having been previously strewed with sand. The moulder, after

dipping his mould into dry sand placed at one corner of his table, throws the prepared lump into the mould, and with a flat smooth stick, about eight inches long, previously dipped in a pan of water, strikes off the surplus soil; he then immediately turns out the brick upon a stand, or board, of the same size with the brick; a boy takes it from thence, and places it on a light barrow, with a lattice work frame fixed over the frame of the barrow, at about three feet high above the wheel, and reduced to about eighteen inches in height towards the handle, forming an inclined plane. The new made bricks are placed on this lattice frame, and over them sand is thrown in sufficient quantities to prevent their adhering to each other, as well as to prevent in a certain degree their cracking in drying, while on the hacks. A boy wheels the barrow to the hacks, and places them with great regularity and dispatch one above the other, a little diagonally, in order to give a free passage to the air. Each hack is made wide enough for two bricks to be placed edgeways across, with a passage between the heads of each brick; they are usually made eight bricks high; the bottom bricks at the end of each hack are old ones.

In showery weather wheat or rye straw is carefully laid over the bricks that are drying on these hacks, to keep them as free from wet as possible; for the brickmakers do not here, as in some places more distant from the metropolis, go to the expense of roofed coverings, or long sheds, which, from the extent of one of these fields, would be impossible.

If the weather is tolerably fine, a few days is sufficient to make them dry enough to be turned, which is done by resetting them more open, and turning them; and six or eight days more are required before they are fit to be put into the clamp, for kilns are not in general use in this part of the country. When sufficiently dry, the clampmaker levels the ground, generally at one end of the range of hacks, nearly centrical, making the foundation of the intended clamp somewhat higher than the surrounding ground; and with place bricks, if they have any, or otherwise with the driest of those just made, makes a foundation of an oblong form, beginning with the flue, which is nearly a brick wide, and running straight through the clamp. In this flue, dry bavins, coals, and cinders (vulgarly called breese), are laid and pressed in close, in order that the interstices between wood and coal may be properly filled up. On the sides of the flue the bricks are placed diagonally, about one inch asunder, and between each layer of bricks three or four inches of breese are strewed, and in this manner they build tier upon tier as high as the clamp is meant to be, never

omitting between each layer, as well as between each brick that is placed diagonally, to put a due portion of breese. When they have made the clamp about six feet long, another flue is made, similar in every respect to the preceding, to the extent of the size of the intended clamp, provided only that the bricks are meant to be burnt off quick, which they will be in about twenty-one or thirty days, according as the weather may suit. But if there is no immediate hurry for the bricks, the flues are placed about nine feet asunder, and the clamp left to burn off slowly. When fire is set to the clamp, and it burns well, the ash-hole being placed at the west end generally, the mouths are stopped with bricks, and clay laid against them; the outsides of the clamps are plaistered with clay if the weather is at all precarious, or the fire burns furiously; and to the end against which addition is made to the clamp, skreens made of reeds worked into frames about six feet high, and sufficiently wide to be moved about with ease, are placed to keep off the weather, and against any particular side where wet is most prevalent. On the top of the clamp a thick layer of breese is uniformly laid.

This is the mode of manufacturing the common grey stocks for walls and common buildings; but some brickmakers, in order to mix the soil and ashes more regularly, perform it with a machine, called a clay-mill, which a horse turns round. This machine consists of a tub or tun fixed to the ground, in which is placed perpendicularly an instrument resembling a worm or screw; the soil being put in at top, is worked down by the rotary motion of the worm, and is forced out at a hole made on the side near the bottom of the tub. A man supplies the tub with fresh soil properly moistened, while the person who supplies the moulder keeps removing that which is prepared, or pressed out.

Washed malms, or more properly marls, are made with still greater attention; a circular walled recess is built about four feet deep, and from three to four feet wide, paved at bottom, and from ten to twelve feet diameter, having a horse-wheel placed in the centre; the ground is raised all round it, and a platform made upon a level with the top of the recess. On this platform the horse walks, a pump is fixed into a well, as near to the platform as may be, to supply the recess with water as often as occasion may require. A barrow made to fit the recess, and thick set with long iron teeth, well loaded, is chained to the traces of the horse, who drags this after him; a man wheels a barrow full of soil previously prepared in a heap, the same as for the common stocks, and shoots it regularly round the recess, he then

pumps a certain quantity of water, which, by means of troughs or shoots, runs on it. The horse is then set in motion, and the barrow being loaded accordingly, forces its way into the soil, admits the water into it, and by thus tearing and separating it, mixes the ingredients at the same time that it gives an opportunity for stones and other ponderous substances to subside to the bottom. The man keeps supplying it with fresh soil and water until there is a sufficient body in the recess. On one side, but as near to the recess as possible, the ground is made smooth, and dug out about eighteen inches or two feet deep into a hollow square, and the soil now becomes paste, and being thereby sufficiently washed, purified, and made fluid, troughs are placed from the recess to this hollow ground, and it is pumped or ladled out with scoops or shovels into the troughs, carefully leaving the sediment at the bottom of the recess to be afterwards thrown out on the sides of it, together with stones, bones, &c. Over this hollow square or pit the fluid soil diffuses itself, where it settles of an equal thickness, and remains until wanted for use; the superfluous water being either evaporated or drained from it, by its being exposed a certain length of time in so thin a body. When they have got a sufficient quantity of washed earth in this pit, another is made alongside of it, and so they proceed until they have got as much thus prepared as they are likely to want during the season.

The clamps for burning these better sorts of bricks are individually the same with the other, but greater care is taken in not overheating the kiln, and in causing it to burn moderately, as equably and as diffusively at the same time as possible.

In the country, bricks are always burnt in kilns, whereby less waste arises, less fuel is consumed, and the bricks are sooner burnt. The bricks are first set or placed in it, and then the kiln being covered with pieces of bricks, or tiles, the workmen put in some wood, to dry them with a gentle fire, and this they continue till the bricks are pretty dry, which takes up two or three days, which is known by the smoke turning from a darkish colour to a transparent smoke; they then leave off putting in wood, and proceed to make ready for burning, which is performed by putting in brush, furze, spray, heath, brakes, or fern faggots, according to the scarcity or plenty of those articles in the neighbourhood. But before they put in any faggots, they dam up the mouth or mouths of the kiln with pieces of bricks, which is called in some places shinlogs, piled upon one another, and close it up with wet brick earth.

The colour of London bricks are not red, as is the case with com-

mon bricks and tiles, but of a light brownish yellow. This colour is more pleasing to the eye than common brick red, and on that account the London bricks are preferred for building houses. The brick-masters assign a curious enough reason for this colour. According to them, their bricks are kept as much as possible from the contact of air during their burning. The consequence of this is, that the iron contained in them is not oxidized to so great a degree as in common bricks. But this mode of reasoning is far from exact. If air were excluded entirely, the bricks would not be burnt at all, because the fire would be extinguished. But if enough air be admitted to burn the coal mixed with the clay, (which must be the case) that air must also act upon the iron, and reduce it to the state of a peroxide. Indeed, there can be no doubt but that the iron in the London yellow bricks is in the state of a peroxide, as well as in the red bricks; for the peroxide of iron gives various colours to bodies, according to circumstances. We find bodies tinged with it, red, yellow, and brown, according to the substances with which the oxide is combined. We ascribe the yellow colour of the London bricks to the ashes of the coals, which, by uniting with the peroxides of iron, form a kind of yellow ochre.

Fire-bricks are made in the same way as common bricks. But the materials are different. The best clay for their composition is Stourbridge clay; and instead of sand, it is usual to mix the clay with a quantity of old fire-bricks, or crucibles, or glass pots, reduced previously to powder. This mixture answers the same purpose as sand, while it does not communicate the tendency to fusion, when it comes in contact with various fluxes, that is communicated by siliceous sand.

There is a kind of bricks mentioned by Pliny, as used by the ancients, which were so light as to swim in water. "Pitanæ in Asia et in ulterioris Hispaniæ civitatibus Maxilua et Calento fiunt. Lateres, qui ciccati non mergunter in aqua."—(*Plinii Natur. Histor. lib.* 35, c. 14.) Pliny does not mention the part of the world in which the earth employed in the manufactures of these bricks was found, though in all probability it could not be far from the cities where the bricks are said by Pliny to have been made. He said the material employed was a kind of pumice stone. But it was quite unknown to the moderns till, in the year 1791, Fabroni found a substance at Castel del Piano, not far from Santa Fiora, situated between Tuscany and the Papal dominions, which formed bricks capable of swimming in water. This is a white earthy matter, which constitutes a bed in that place, and was known in Italy by the name of Latie di Luna.

In addition to the modes of manufacturing bricks, to which we have already called the reader's attention, there are several patents for improved machinery connected with the process.

Two of these may now be examined. Mr. Hague's patent is for an improvement in mixing of the materials, and consists in separating from the clay the stones, roots, and other extraneous matter it may contain, which is effected by forcing the clay through holes or slits, as of a cullender or sieve, by which all substances which are larger than the apertures are retained, and only the clear clay delivered out through the interstices.

The machinery proposed in the specification consists of a square trunk, strongly made, its sides being occupied, between the framing, with bars or wires, set a small space asunder; into this trunk the materials to be prepared are put. A piston is then forced into the trunk down upon the clay, by which it is pressed out through the apertures, cleansed of all extraneous substances. At the bottom of the trunk is a box, in which the stones, roots, &c remain; and these are removed by opening a door provided for that purpose.

The piston is worked by means of a rack attached to it, and a pinion taking into the rack, upon a shaft, which is to communicate, by any of the known methods, with a steam-engine, water-wheel, horse-wheel, or other power; and is put in or out of action by a clutch-box sliding upon the shaft. A pin is fixed in the back of the rack, in such a situation, that, as the piston approaches the bottom of the trunk, this pin may bear upon a lever, and disengage the clutch-box, by which the action of the machine is stopped. By a reverse motion, or some other contrivance, the piston is again raised, when the trunk must be supplied with more materials to be operated upon as before.

The patentee further states, that he proposes to form bricks and tiles by having holes, at the bottom of the machine, the size of the end of the brick or tile, which are to be cut off by a wire as they come out of the holes.

The other contrivance is by Mr. Shaw, and this we understand is, with some modifications, likely to be adopted on a large scale. Mr. S.'s machinery for the making of bricks consists of a frame carrying a horizontal piston or press, which forces the clay (supplied from a hopper) into a mould or box, properly shaped, thus forming the brick. The action of the piston is obtained by two bars connected together, forming an elbow-joint, the angle of which is more or less straightened by the revolution of an eccentric wheel having its peri-

phery working against the joint of the two bars, and hence, as its larger radius comes against the joint, causing it to rise, by which the angle that the bars make with each other will become more obtuse; as a consequence they will elongate, and press against the piston, to which the end of one of the bars is connected, and thus press the clay into the mould or box.

From a rigger communicating with the first mover, a band is carried, which turns an axle (having many arms) placed over the hopper, by which the clay that is from time to time put into the hopper, is cut in small pieces, and forced down into the mould-box before mentioned. Thus the clay is supplied to the mould-box by being forced down through the hopper, and the brick is formed by the force of the connected bars, which press it into form when in the mould. There is a contrivance for pushing out the brick, when made, from the mould, by means of a stud acting against a lever, which opens the end of the mould-box, and the bricks are then received, one by one, on an endless web which conveys them away from the machine.

This apparatus may be moved by any of the known means of manual, horse, or steam power, &c. and may have a fly-wheel to equalize its motion.

Having in the preceding pages examined the various modes of making bricks which have been practised with advantage in this country, it may now be advisable to direct the reader's attention to the composition of *mortar* and other *cements*.

Mr. Dossie, in the second volume of the Memoirs of Agriculture, gives the following method of making mortar impenetrable to moisture, acquiring great hardness, and exceedingly durable, similar to that used by the ancients, which was discovered by a gentleman of Neufchatel: take of unslaked lime and of fine sand, in proportion of one part of the lime to three parts of the sand, as much as a labourer can well manage at once, and then adding water gradually, mix the whole well together with a trowel till it be reduced to the consistence of mortar. Apply it immediately, while it is hot, to the purpose, either of mortar, as a cement to brick or stone, or of plaster to the surface of any building. It will then ferment for some days in dry places, and afterwards gradually concrete, or set, and become hard: but in a moist place it will continue soft for three weeks or more; though it will at length attain a firm consistence, even if water have such access to it, so as to keep the surface wet the whole time. After this, it will acquire a stone-like hardness, and resist all

moisture. The perfection of this mortar depends on the ingredients being thoroughly blended together, and the mixture being applied immediately after to the place where it is wanted. The lime for this mortar must be made of lime-stone, shells, or marl; and the stronger it is, the better the mortar will be; besides, the lime should be carefully kept from the access of air or wet, otherwise, by attracting moisture, it will lose proportionably that power of acting on the sand, by which the incorporation is produced. It is proper also to exclude the sun and wind from the mortar for some days after it is applied, that the drying too fast may not prevent the due continuance of the fermentation, which is necessary for the action of the lime on the sand. When a very great hardness and firmness are required in this mortar, the use of skimmed milk instead of water, either wholly or in part, will produce the desired effect, and render the mortar extremely tenacious and durable.

M. Loriot's mortar, the making of which was announced by order of His Majesty at Paris in 1774, is made in the following manner: take one part of brick-dust finely sifted, two parts of fine river-sand skreened, and as much old slaked lime as may be sufficient to form mortar with water in the usual method, but so wet as to serve for the shaking of as much powdered quick-lime, as amounts to one-fourth of the whole quantity of brick-dust and sand. When the materials are well mixed, employ the composition quickly, as the least delay may render the application of it imperfect or impossible. Another method of making this composition is, to make a mixture of the dry materials: *i. e.* of the sand, brick-dust, and powdered quick-lime, in the prescribed proportion, which mixture may be put in sacks, each containing a quantity sufficient for one or two troughs of mortar. The above mentioned old slaked-lime and water being prepared apart, the mixture is to be made in the manner of plaster, at the instant when it is wanted, and is to be well chafed with the trowel. With respect to this method, Dr. Higgins observes, that M. Loriot corrects the bad quality of the old and effete lime, which constitutes the basis of his mortar, and which has regained a part of the fixed air that had been expelled from it, by the addition of fresh and non-effervescent lime, hastily added to it at the time of using the composition, which must undoubtedly improve the imperfect mass. And he adds, that when an ignorant artist makes mortar with whiting instead of lime, he can mend it considerably by adding lime to it; but his mortar will still be defective in comparison with the best that can be made, by reason of the old slaked-lime or whiting; this, on repeated trials, he has found

to be the true state of the case. Dr. Higgins has made a variety of experiments in consequence of the modern discoveries relating to carbonic acid or fixed air, for the purpose of improving the mortar used in our buildings. According to this author, the perfection of lime prepared for the purpose of making mortar, consists chiefly in its being totally deprived of its fixed air. On examining several specimens of the lime commonly used in building, he found that it was seldom or never sufficiently burned, for they all effervesced, and yielded more or less fixed air, on the addition of an acid, and slaked slowly in comparison with well burned lime. Dr. Higgins also relates some experiments, which shew how very quickly lime imbibes fixed air from the atmosphere, on its exposure to which it by degrees soon loses those characters which chiefly distinguish it from mere lime-stone or powdered chalk, by soon attracting from thence that very principle, to the absence of which it owes its useful quality as a cement, and which had before been expelled from it in the burning. Hence he concludes, that as lime owes its excellence to the expulsion of fixed air from it in the burning, it should be used as soon as possible after it is made, and guarded from exposure to the air as much as possible before it is used. It is no wonder, therefore, he says, that London mortar is bad, if the imperfection of it depended solely on the badness of the lime; since the lime employed in it is not only bad when it comes fresh from the kiln, because it is insufficiently burned, and the air has access to it, but becomes worse before it is used, by the distance and mode of its conveyance, and when slaked, is as widely different from good lime as it is from powdered chalk. For a similar reason, every other cause which tends to restore to the lime, the fixed air of which it had been deprived in the burning, must depreciate it.

It must receive this kind of injury, for instance, from the water, so largely used, first, in slaking the lime, and afterwards in making it into mortar, if that water contains fixed air, from which few waters are perfectly free, and which will greedily be attracted by the lime. The injury arising from this cause is prevented by the substitution of lime-water, so far as it may be practicable or convenient.

From other experiments, made with the view of ascertaining the best relative proportions of lime, sand, and water, in the making of mortar, it appeared that those specimens were the best that contained one part of lime in seven of the sand; for those which contained less lime, and were too short whilst fresh, were more easily cut and broke, and were pervious to water; and those which contained more lime, although they were closer in grain, did not harden so soon, or to so

great a degree, even when they escaped cracking by lying in the shade to dry slowly. It appeared farther, that mortar, which is to be used where it must dry quickly, ought to be made as stiff as the purpose will admit, or with the smallest practicable quantity of water, and that mortar will not crack, although the lime be used in excessive quantity, provided it be made stiffer, or to a thicker consistence than mortar usually is.

Dr. Higgins has also shewn, that though the setting of mortar, as it is called by the workmen, chiefly depends on the exciccation of it, yet its duration, or its acquiring a stony hardness, is not caused by its drying, as has been supposed, but is principally owing to its absorption of fixed air from the atmosphere, and is promoted in proportion as it acquires this principle, the accession of which is indispensably necessary to the induration of calcareous cements. In order to the greatest induration of mortar, therefore, it must be suffered to dry gently and set; the exsiccation must be effected by a temperate air, and not accelerated by the heat of the sun or fire; it must not be wetted soon after it sets; and afterwards it ought to be protected from wet as much as possible, until the mortar is finally placed and quiescent; and then it must be as freely exposed to the open air as the work will admit, in order to supply acidulous gas, and enable it sooner to sustain the trials to which mortar is exposed in cementing buildings, and other incrustations.

Dr. Higgins has also inquired into the nature of the best sand or gravel for mortar, and into the effects of bone-ashes, plaster, powder, charcoal, sulphur, &c. and he deduces great advantages from the addition of bone-ashes, in various proportions, according to the nature of the work for which the composition is intended.

This author describes a water cement or stucco, of his own invention, for incrustations internal and external, exceeding, as he says, Portland stone in hardness, for which he obtained His Majesty's letters patent. As for the materials of which this is made; drift sand or quarry sand, or, as it is commonly called, pit sand, consisting chiefly of hard quartose flat-faced grains, with sharp angles, the most free from clay, salts, and calcareous, gypseous, or other grains less durable than quartz, containing the smallest quantity of heavy metallic matter, and admitting the least diminution in bulk by washing, it is to be preferred to any other. The sand is to be sifted in clear water, through a sieve which shall give passage to all such grains as do not exceed one-sixteenth of an inch in diameter: and the stream of water and sifting are to be so regulated, that all the sand, which is much

finer than the Lynn sand, together with clay and other matter, specifically lighter than sand, may be washed away with the stream, whilst the purer and coarser sand, which passes through the sieve subsides in a convenient receptacle; and whilst the coarse rubbish and shingle remain on the sieve to be rejected. The subsiding sand is then washed in clean water, through a finer sieve, so as to be farther cleansed and sorted into parcels, a coarser, which will remain in the sieve, which is to give a passage to such grains of sand only as are less than one-thirteenth of an inch in diameter, and which is to be saved apart under the name of coarse sand; and a finer, which will pass through the sieve and subside in the water, and which is to be saved apart under the name of fine sand. These are to be dried separately, either in the sun, or on a clean iron plate set on a convenient surface, in the manner of a sand heat. Let the *lime* be chosen, which is stone-lime, which heats the most in slaking, and slakes the quickest when duly watered, which is the freshest made, and most closely kept; which dissolves in distilled vinegar with the least effervescence, and leaves the smallest residue insoluble, and in this residue the smallest quantity of clay, or gypsum. Let this lime be put in a brass-wired fine sieve, to the quantity of fourteen pounds. Let the lime be slaked by plunging it in a butt filled with soft water, and raising it out quickly and suffering it to heat and fume, and by repeating this plunging and raising alternately, and agitating the lime until it be made to pass through the sieve into the water: reject the part of the lime that does not easily pass through the sieve, and use fresh portions of lime, till as many ounces of lime have passed through the sieve, as there are quarts of water in the butt. Let the water thus impregnated stand in the butt, close covered, until it becomes clear; and, through wooden cocks placed at different heights in the butt, draw off the clear liquor as fast and as low as the lime subsides, for use: this clear liquor is called the cementing liquor. Let fifty-six pounds of the foresaid chosen lime be slaked, by gradually sprinkling on it, and especially on the unslaked pieces, the cementing liquor, in a close clean place. Let the slaked part be immediately sifted through the fine brass-wired sieve. Let the lime which passes be used instantly, or kept in air-tight vessels, and let the part of the lime which does not pass through the sieve be rejected: the other part is called purified lime. Let bone-ash be prepared in the usual manner by grinding the whitish burnt bones, but let it be sifted much finer than the bone-ash commonly sold for making cupels. Having thus prepared the materials,

take fifty-six pounds of the coarse sand, and forty-two pounds of fine sand; mix them on a large plank of hard wood placed horizontally: then spread the sand so that it may stand to the height of six inches, with a flat surface, on the plank; wet it with the cementing liquor; to the wetted sand add fourteen pounds of the purified lime, in several successive portions, mixing and beating them together; then add fourteen pounds of the bone-ash in successive portions, mixing and beating all together.

This Dr. Higgins calls the water-cement coarse grained, which is to be applied in building, pointing, plastering, stuccoing, &c. observing to work it expeditiously in all cases, and in stuccoing to lay it on by sliding the trowel upwards upon it; to well wet the materials used with it, or the ground on which it is laid, with the cementing liquor at the time of laying it on; and use the cementing liquor for moistening the cement and facilitating the floating of it.

Fresh made mortar, if kept from the air under ground in considerable masses, may be preserved a great length of time without injury, and the older it is before it is used the better, the builder taking the precaution to beat it up afresh previous to using it, for it not only sets sooner, but acquires a greater degree of hardness, and is less apt to crack. A fact related by Mr. Smeaton, remarkably illustrates these points. Having had occasion to take up a large flat stone of a close grain, of about five feet square, that had probably lain above a century at the bottom of a malt cistern, he found that it had been well bedded in mortar, which had become coagulated to the consistence of cheese; but having never come to a perfect dryness, it so far retained its natural humidity, that he found it might, with some pains, be beaten up to mortar without any addition of water; and afterwards, being suffered to dry in the air, it set to a stony hardness, and appeared as good mortar as any which that part of the country could produce. Pliny informs us, that the ancient Roman laws prohibited builders from using mortar that was less than three years old; and to this circumstance he expressly attributes the remarkable firmness of the oldest buildings in the city. A similar custom prevailed, and indeed still prevails in Vienna, requiring the mortar to be a year old before it is employed. But there is nothing which shews, in so striking a point of view, the advantage and necessity of beating mortar, and the effect produced is owing to something more than a mere mechanical mixture of ingredients, as the preparation of grout, or liquid mortar. This differs from common mortar, only in containing a larger quantity of water, so as to be sufficiently fluid to penetrate the narrow irregular

interstices of rough stone walls, and is generally made by diluting common mortar with water, either cold or hot. It not unfrequently happens, that this refuses to set, and at all times it is a long while in acquiring the proper hardness; but if, instead of common mortar, that which has been long and thoroughly beaten is employed, the grout will set in the space of a day, and soon after acquires a degree of hardness much superior to what is made in the common manner.

Mortar which sets without cracking, whether this be owing to the due proportion of sand, or to the slow exhalation of the water from mortar containing less sand, never cracks afterwards, whatever its faults, in other respects, may be. As it is the lime paste, and not the sand, which contracts and produces fissures in drying, so the more sand there is in the composition, the less the cracks will be seen. Mortar which is liable to crack, becomes irreparably injured by frequent alternations of wetting and freezing; for the water imbibed by the smallest fissures, dilating as it congeals, loosens its whole texture. Where, however, it is composed of seven parts of sorted sand, to one of lime, it is not disposed to crack.

To shew more clearly how much our slight buildings are weakened by the agitations and percussions to which they are exposed, first in erecting the walls and settling the timbers, and then in driving those wedges to which the wainscots, mantlepieces, and other ornaments, are fastened, we must observe, that the absorption of carbonic acid by mortar contributes nothing to the strength of it, if it enter before it is finally fixed in a quiescent state. A little experience is sufficient to teach us, that the same matter which assists in the induration of mortar, never serves to repair the fissures, or solution of continuity between the bricks and cement, which happens after it is set. When mortar is set, and before it is indurated, it may be easily severed from the bricks and crumbled; and for want of softness, it cannot bend into the fissures, or resume its former condition in any time. Hence, by heavy blows, and in wedging, our walls must be greatly weakened; and the more so, as the houses are slight, quickly built, and hastily finished.

Nothing is more common than for bricklayers to keep their mortar some time exposed to the air in heaps, before they consider it proper to use; a practice which may perhaps be accounted for, if we consider that some portions of every kind of lime used in this country, do not slake freely, by reason of their not being sufficiently burned, or the admixture of gypseous or argillaceous matter; which portions, like marl, slake in time, though not so quickly as the purer lime. The

plasterers, who use a finer kind of mortar, made of sand and lime, observe that their stuccó blisters, if it contain small bits of unslaked lime, and as smoothness of surface is with them of more consequence than excessive hardness, they take care to secure the perfect slaking of their lime by allowing sufficient time for the imperfect parts to be penetrated by the moisture. The bricklayers, trusting, perhaps, more to the judgment of the plasterers, in this respect, than to their own, and considering it very convenient to slake a large quantity of lime at once, follow the same practice, without caring for or apprehending the real fact, that mortar, when exposed to the air, is worse for every hour it is kept, and that they are taking such measures as will prevent it from ever acquiring that degree of hardness in which its perfection consists.

Among the circumstances which contribute to the speedy ruin of modern buildings, it may also be observed, that mortar made with bad lime, and a great excess of it, is used with dry bricks, and not unfrequently with warm ones. These immediately imbibe or dissipate much of the water, and as the cement approaches nearer to be dry, whilst it is still liable to be displaced by the percussions of the workmen, render it little better than equivalent to a mixture of sand and powdered chalk. To make strong work, the bricks ought to be soaked in lime-water, and freed from the dust with which they are commonly covered. By this means the bricks are rendered closer and harder, the cement, by setting slowly, admits the motion which the bricks receive when the workman dresses them, without being impaired, and it adheres and indurates more perfectly. This steeping of the bricks is an imitation of the practice of the plasterers, who always wet the wall before they commence their work, because they know the cement will not otherwise adhere. This ought to be done as long as the wall is thirsty, and lime-water is the most proper liquid they can use. The same advantage that attends the soaking of bricks, would attend the soaking of bibulous stones in lime-water.

Mortar made with sand containing one-seventh or one-eighth of fat clay, moulders in winter like marl; a circumstance which proves the propriety of freeing from clay the sand used in mortar. The washing performed for this purpose, would be found a very cheap operation, even in cities, if the water which carries off the clay be directed into a receptacle where it may be depurated by subsidence for repeated use.

Chalk lime may be easily prepared, so as to be fully equal if not superior to stone lime. The reason why this is not generally thought to be the case, probably is, that not being of so close a texture, it is

sooner spoiled by the absorption of carbonic acid, when exposed to the atmosphere after it is made. A cask of chalk lime should therefore never be opened till the moment it is to be slaked, and the greatest expedition should be used in the slaking, and in the making and applying the mortar to use. In the quiescent air of a room, a pound, avoirdupois, of chalk lime, becomes two ounces and a half heavier in two days; and nearly the whole of this increase of weight, consists of the carbonic acid which it has imbibed from the atmosphere.

The fittest water for making mortar, is rain water; river water holds the next place; land water the next; spring water the last; sea water, and all waters noticed medicinally or otherwise, for their saline contents, ought never to be used for this purpose.

Tarras is frequently used in this country, being imported from Holland for that purpose. The proportions of the materials of the *tarras mortar* generally used in the construction of the best water-works is the same as the Dutch practice. One measure of quick-lime, or two measures of slaked-lime in the dry powder, is mixed with one measure of tarras, and both very well beat together, to the consistence of a paste, using as little water as possible. Another kind, almost equally good, and considerably cheaper, is made of two measures of slaked lime, one of tarras, and three of coarse sand; it requires to be beaten a longer time than the foregoing, and produces three measures and a half of excellent mortar. When the building is constructed of rough irregular stones, where cavities and large joints are to be filled up with cement, the pebble mortar may be most advantageously applied; this was a favourite mode of construction among the Romans, and has been used ever since their time in those works in which a larger quantity of mortar is required. Pebble mortar will be found of sufficient compactness if composed of two measures of slaked argillaceous lime, half a measure of tarras, or puzzolana, one measure of coarse sand, one of fine sand, and four of small pebbles, screened and washed.

It is only under water that tarras mortar acquires its proper hardness; for, if suffered to dry by exposure to the air, it never sets into a substance so firm as if the same lime had been mixed with good clean common sand, but it is very friable and crumbly. Ash mortar is reckoned to be superior for works that are sometimes wet and sometimes dry, but tarras has the advantage when constantly under water. Tarras mortar, when kept always wet, and consequently in a state most favourable to its cementing principle, throws out a substance

something like the concretions in limestone caverns, which substance acquires a considerable hardness, and in time becomes so exuberant as to deform the face of the walls.

The first thing to be considered when a building is about to be erected, is the *foundation.*

If there are cellars or underground kitchens, it is commonly found that they are of sufficient depth to find a good and solid foundation; but where this is not the case, the remedies are to dig deeper, or to drive in large stones with the rammer, or by laying in thick pieces of oak, crossing the direction of the wall, and planks of the same timber, wider than the intended wall, and running in the same direction with it. These last are to be spiked firmly to the cross pieces, to prevent their sliding, the ground having been previously well rammed under them.

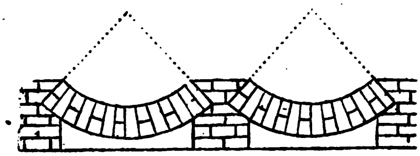
The mode of ascertaining if the ground be solid, is by the rammer; if by striking the ground with this tool, it shake, it must be pierced with a borer, such as is used by well-diggers; and having found how deep the firm ground is below the surface, you must proceed to remove the loose or soft part, taking care to leave it in the form of steps if it is tapering, that the stones may have a solid bearing, and not be subject to slide, which would be likely to happen if the ground were dug in the form of an inclined plane.

If the ground prove variable, and be hard and soft at different places, the best way is to turn arches from one hard spot to another. Inverted arches have been used for this purpose with great success, by bringing up the piers which carry the principal weight of the building to the intended height and thickness, and then turning reversed arches from one pier to another. It is clear that by this means the piers cannot sink without carrying the arches, and consequently the ground on which they stand with them. This contrivance was recommended by Alberti, and was adopted by Mr. Hook, in building Montague House, and is not often omitted, where circumstances of the kind before stated occur, and where the architect employed has any regard to his own or his employer's interest.

Where the hard ground is only to be found under apertures, build your piers on these places, and turn arches from one to the other. In the construction of the arches some attention must be paid to the breadth of the insisting pier, whether it will cover the arch or not; for suppose the middle of the piers to rest over the middle of the summit of the arches, then the narrower the piers the more curvature

the supporting arch ought to have at the apex. When arches of suspension are used, the intridos ought to be clear, so that the arch may have the full effect; but, as observed before, it will also be requisite here that the ground be uniformly hard on which the piers are erected, for it is better that it should be uniform, though not so hard as might be wished, than to have it unequally so; for in the former case the piers would descend uniformly, and the building remain uninjured; but in the latter, a vertical fracture would take place, and endanger the whole edifice.

Before we quit the subject of brick walls, especially with regard to the foundations of a building, it may, however, be advisable briefly to revert to the use of an inverted arch. Thus we find in the diagram beneath, three walls, so arranged as to be capable of supporting a superstructure of five times their own extent when employed individually.



The foundation being ready, according to the foregoing directions, the destination, or use of the building, with its magnitude, &c. must be considered, in order to use such materials as are best suited to the end required, and as the making of mortar is so important a feature in the work, we will again call the reader's attention to the subject. In slacking lime, use only as much water as will reduce it to a powder, and only about a bushel of lime at a time, covering it over with sand, in order to prevent the escape of carbonic acid.

This is a better mode than slacking the whole at one time, as there is less surface exposed to the air. Before you use the mortar, it should be beat three or four times over, so as to incorporate the lime and sand, and to reduce all knots or knobs of lime that may have passed the sieve. This very much improves the smoothness of the lime, will make the mortar stronger; as little water is to be used in this process as possible. Whenever mortar is suffered to stand any time before used, it should be beat again, so as to give it tenacity, and prevent labour to the bricklayer. In dry hot summer weather use your mortar soft, in winter rather stiff.

If you lay your bricks in dry weather, and the work is required to

be firm, wet your bricks by dipping them in water, or by causing water to be thrown over them before they are used, and your mortar should be prepared in the best way. Few workmen are sufficiently aware of the advantage of wetting bricks before they are used, but experience has shewn that works in which this practice has been attended to, have been much stronger than others where it has been omitted. It is particularly serviceable where work is carried up thin, or in putting in furnaces, grates, &c.

In winter, as soon as frosty and stormy weather set in, cover your wall with straw or boards; the former is better than the latter, if well secured, as it protects the top of the wall in some measure from frost, which to a building is very prejudicial, particularly when it follows much rain; for the rain penetrates to the heart of the wall, and the frost, by converting the water into ice, expands it, and causes the mortar to assume a short and crumbly nature, and altogether destroys its tenacity.

In working up the wall it will be proper not to work more than four or five feet at a time, for as all walls, immediately after building, shrink, the part which is first brought up will remain stationary, and when the adjoining part is raised to the same height, a shrinking or settling will take place, and separate the former from the latter, causing a crack which will become more and more evident as the work proceeds. In carrying up any particular part, each side should be sloped off, to receive the bond of the adjoining work on the right and left. Nothing but absolute necessity can justify the work being carried higher in any particular part than one scaffold, for, wherever it is done, the workman is certainly answerable for all the evil which may arise from such palpable error.

The term *bond* is applied to any disposition of the bricks, by which the continuity, in a straight line, of the joints of a wall is interrupted. It is obvious that a bond may be adopted, which will interrupt the rectilinear direction of both the horizontal and vertical joints of a wall; but in the two kinds of bond which have hitherto prevailed, the horizontal joints are continued in the same line round the whole building, and the vertical ones only interrupted. When the wall is only intended to be half a brick, or four inches and a half in thickness, the whole of the bricks are laid so as to form stretchers, that is, their length is laid in the direction of the length of the wall, and the bond is obtained simply by making the vertical joints in every course exactly opposite the middle of the bricks above and below. But when

the wall is intended to be the length of a brick or more in thickness, it would be apt to split into parts if it consisted only of two or more walls separately bonded, as in the instance just mentioned of the half brick wall. The bricks, therefore, in thick walls, must be connected in their breadth as well as their length, and this is done according to two principal modes, one of which is called English, and the other Flemish bond.

The two kinds of bond in brick work differ materially from each other, and as the subject is of the highest importance to the bricklayer, we shall lay before our readers some excellent remarks contained in a pamphlet written on this subject, by Mr. G. Saunders, who has treated it with a degree of attention which its importance requires.

"Bricks laid lengthways in the direction of the wall are called stretchers, and those laid in an opposite way, crossing the direction of the wall, are called headers.

"Old English bond is a continuation of one kind throughout in the same course or horizontal layer, and consists of alternate layers of headers and stretchers, the headers serving to bind the wall together in a longitudinal direction, or lengthways, the stretchers, to prevent the wall splitting crossways, or in a transverse direction. Of these two evils, the former is by much the worst kind, and is therefore most dreaded by the bricklayer."

Mr. Saunders is of opinion, that old English brickwork is the best security against these accidents, as work of this kind, wheresoever it is so much undermined as to cause a fracture, is not subject to either of the above evils, but separates by breaking through the solid brick, just as if the wall were composed of one entire piece.

The brick work of the Romans was of this kind of bond, but the specimens of their work which remain are of great thickness, and have three, or sometimes more, courses of brick laid at certain intervals of the height, stretchers on stretchers, and headers on headers, opposite the return wall, and sometimes at certain distances in the length, forming piers, that bind the wall together in a transverse direction; the interval between these piers were filled up, and formed pannels of rubble or reticulated work; consequently great substance with strength was economically obtained.

Flemish bond, which is the second kind, consists in placing in the same course alternate headers and stretchers, which disposition, according to our author, is decidedly inferior in every thing but in ap-

pearance, and even in this the difference is so trifling, that few common observers would be struck with any great superiority that the former possesses over the latter. To obtain this, strength is sacrificed, and bricks of two qualities are fabricated for the purpose; a firm brick often rubbed and laid in what the workmen term a putty joint, for the exterior, and an inferior brick for the interior substance of the wall; as these did not correspond in thickness, the exterior and interior surface of the wall would not be otherwise connected together, than by an outside heading brick that was here and there continued of its whole length; but as the work does not admit of this at all times, from the want of agreement in the exterior and interior courses; these headers can only be introduced where such a correspondence takes place, which sometimes may not occur for a considerable space.

Walls of this kind consist of two faces of four inch work, with very little to connect them together, and what is still worse, the interior face often consists of brick, little better than rubbish. Notwithstanding this, the practice of Flemish bond has continued from the time of William and Mary, when it was introduced, with many other Dutch fashions; and our workmen are so infatuated with this practice, that there is scarcely an instance to be seen of the old English bond.

To the Flemish bond alone must be attributed the frequent splitting of walls into two thicknesses, and various schemes have been from time to time adopted for the prevention of this formidable defect. Some have laid laths or slips of hoop iron occasionally in the horizontal joints between the two courses; others lay diagonal courses of bricks at certain heights from each other; but the good effect of this last practice is much doubted as in the diagonal course, by their not being continued to the outside, the bricks are much injured where the strength is most wanted.

Many other practices are enumerated to unite complete bond with Flemish facings, but with no better success. The interior bricks are disposed with an intention to unite these two particulars, the Flemish facings being only on one side of the wall; but this at least falls far short of the strength obtained by the English manner. There is another evil attending this disposition of the brick, which is the difficulty of its execution, as the adjustment of the bricks in one course must depend on the course beneath, which must be seen or recollected by the workman; the first is difficult, from the joints of the under course being covered with mortar, to bed the bricks of the succeeding course, and for the workman to carry in his mind the arrange-

ment of the preceding course, is more than can reasonably be expected from him, and, unless it be attended to, the joints will be frequently brought to correspond, dividing the wall into several thicknesses, and rendering it subject to separation or splitting.

In the old English bond, the outside of the last course points out how the next is to be laid, so that the workman cannot easily err.

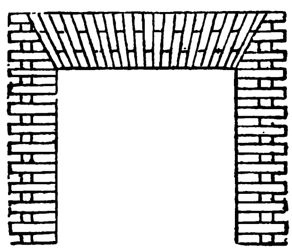
The outside appearance is all that can be urged in favour of Flemish bond, but even in this Mr. Saunders is of opinion, that were the English manner executed with the same attention and neatness that is bestowed on the Flemish, it would be considered as equally handsome. However this may be, it is surely the duty of all who are concerned in this business to recommend the adoption of the old English bond, and the following are directions for the execution of it.

1st. Each course to be alternately of headers and stretchers.

2nd. Every brick in the same course must be laid in the same direction; but in no instance is a brick to be placed with its whole length along the side of another, but to be so situated, that the end of one may reach to the middle of the others which lay contiguous to it, except the outside of the stretching course, where three-quarter bricks necessarily occur at the ends, to prevent a continued upright joint in the face work.

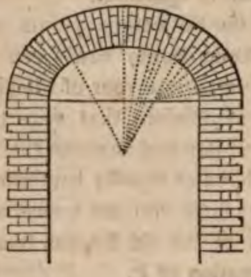
3rd. A wall which crosses at a right angle with another, will have all the bricks of the same level course in the same parallel direction, which completely bonds the angles.

The mode of combining the parts of an arch, as applicable to the general purposes of a bricklayer, may now be examined: the scientific principles on which it is constructed will, however, be more fully examined in that department of our work exclusively devoted to *bridge building*.



The straight arch, as is seen above, consists of a series of wedge-formed bricks, although the bricks at either extremity taper less than

those in the centre. The scheme arch, two bricks high, and the elliptic arch, struck from two centres, as represented by the radiating lines, are also occasionally employed with advantage.



In pursuance of our plan, we now direct the reader's attention to that part of the roof which more immediately comes under the notice of the bricklayer, *viz.* the covering with *tiles.*

In the interior of the county of Surrey, tiles are almost uniformly used for roofs of houses, and in some instances, on barns; but, between Dorking and Horsham, a heavy, but very durable sort of slate-stone is used. Nearer London, slates, either Welsh or Westmoreland, prevail. As there are many persons who give the preference to tiles, it may not be amiss to give the result of a curious experiment on that subject, as related by the bishop of Landaff.

"That sort of slate, other circumstances being the same, is esteemed the best which imbibes the least water; for the imbibed water not only increases the weight of the covering, but in frosty weather being converted into ice, it swells and shivers the slate. This effect of frost is very sensible in tiled houses, but is scarcely felt in those which are slated; for good slate imbibes but little water, and when tiles are well glazed, they are rendered in some measure, with respect to this point, similar to slate. I took a piece of Westmoreland slate, and a piece of common tile, and weighed each of them carefully: the surface of each was about thirty square inches; both the pieces were immersed in water for about ten minutes, and then taken out and weighed as soon as they had ceased to drip; the tile had imbibed above a seventh part of its weight of water, and the slate had not imbibed a two-hundredth part of its weight; indeed the wetting of the slate was merely superficial. I placed both the wet pieces before the fire; in a quarter of an hour the slate was become quite dry, and of the same weight it had before it was put into the water; but the tile had lost only about twelve grains of water it had imbibed, which was,

as near as could be expected, the very same quantity that had been spread over its surface; for it was the quantity which had been imbibed by the slate, the surface of which was equal to that of the tile; the tile was left to dry in a room heated to sixty degrees, and it did not lose all the water it had imbibed in less than six days.

The finest sort of blue slate is sold at Kendal for 3*s*. 6*d*. per load, which comes to 1*l*. 15*s*. per ton, the load weighing two hundred weight.—The coarsest may be had for 2*s*. 4*d*. a load, or 1*l*. 3*s*. 4*d*. per ton. Thirteen loads of the finest sort will cover forty-two square yards of roof, and eighteen loads of the coarsest will cover the same space: so that there is half a ton less weight upon forty-two square yards of roof when the finest slate is used, than if it was covered with the coarsest kind, and the difference of the expense of the material is only 3*s*. 6*d*. To balance in some measure the advantage arising from the lightness of the finest slate, it must be remarked, that it owes its lightness, not so much to any diversity in the component parts of the stone from which it is split, as to the thinness to which the workmen reduce it; and it is not able to resist violent winds so well as that which is heavier.

A common Cambridge tile weighed thirty-seven ounces: they use at a medium 700 tiles for covering 100 square feet, or about two and a half tons of tile to forty-two square yards. Hence, without including the weight of what is used in wrapping over, &c. when a building is covered with copper or lead, it will be seen that forty-two square yards of building will be covered by,

	Cwt.
Copper	4
Fine Slate	26
Lead	27
Coarser Slate	36
Tiles	54

From the foregoing statement it is evident, that the consequences arising from a covering with tiles are two-fold; the first, that owing to the weight of them, we are obliged to make our plates and rafters of the roofs, so much stouter and heavier than there is any occasion to do for slates, even of the coarser sort; and consequently this increased strength in the timber must add to the expense of the roof, supposing that the same thickness of wall be sufficient. Secondly, it is proved, that from the porosity of the tile, it imbibes one-seventh part of its weight, or about five ounces of water in ten minutes, and that it requires the heat of sixty degrees, which is five degrees

above temperate, and six days to make the tile as dry as it was before it was saturated. How much longer the tile may continue wet, during the moist winter months, if it ever dries at all upon the roofs of our houses, is a question we are not prepared to explain. But Mr. Malcolm thinks, that tiles in a damp state, lodging on timber for at least six months, must injure the timber, and, together with the unburnt, or place bricks in the walls, must produce an almost perpetual moisture, and make a house damp and unhealthy at all seasons.

Taking for granted that the bricklayer is sufficiently acquainted with the ordinary mode of constructing a scaffold calculated for raising the walls of any edifice, we proceed to notice a very ingenious contrivance, by which the pointing and other necessary repairs of a house may be performed at a comparatively small cost.

This simple and effective contrivance may be best understood by reference to *Plate* VIII. and consists of nothing more than a couple of planks, A, to which two others, B B, are nailed, forming a sort of trough, or moveable scaffold, on which the workmen stand, which is suspended at any height at pleasure. C C and D D are two frames of wood, in which the trough or scaffold is fixed; in the top cross-pieces of these frames two pullies, E and F, are fitted, and round these the ropes by which the scaffold is suspended are passed; the ends, *a a*, of these ropes are made fast to two beams, or scaffold poles, G and H, which project out of the upper windows: or they may be fixed over the parapet, or by any other means, as is thought proper; two single pully-blocks, *g g*, are also suspended from these poles, and the rope, after passing under the pullies, E and F, passes over the pullies in these two blocks, and the ropes or falls, *h* and *i*, come down to the machine, and are made fast to any convenient part of it; therefore, by drawing these ropes, the workmen can, with the greatest ease, raise or depress the suspended scaffold to any place where it is wanted for work.

Another scaffold, for repairing *domes*, will be found in the same plate. It was contrived by Mr. Hughes, and the invention was rewarded by the Society for the Encouragement of Arts, &c.

This scaffold is made to move round on an upright pole, in the centre of the dome, and on two wheels running on the floor, so that it can be turned to all parts of the dome. Fig. 2 of Plate VIII. represents an oblique elevation of the scaffold, as erected in the dome, R R, of the building, S. The chief support is a straight scaffold pole, A A, which turns on a pivot at the top, supported by a piece of wood fixed across the top of the dome in the centre, and is supported

at the bottom on another pivot, resting in a step of wood fixed on the floor. To this pole a light braced frame is fixed, and traverses round on two rollers, B B; these are situated at the bottom of the two upright legs, K K, which are nearly as high as the walls of the building. The tops of these support the ends of the two curved planks, C C, the upper ends of which are bolted on each side of the centre pole at D. Between these planks a number of boards or planks are placed horizontally, so as to form a scaffold, on which the workmen stand to work round the interior of the dome, at any height they find convenient. The width of these steps gradually diminish from the space between the two uprights, B B, to a very small point at the pole near D. The whole is braced by two diagonal stays, I I, extending from the bottom of the uprights, B B, and secured to the upper part of the pole at E. The curved planks, C C, are also strengthened and supported by the short braces, F F, G G, and H H, which extend from the stays, I I, to the curves C C; these form a strong and secure scaffold, which may be easily moved round to any part of the internal dome at pleasure. To strengthen the frame sideways, diagonal braces are applied between the two uprights, K K.

We may now turn to that important branch of the art of bricklaying which relates to the construction of *furnaces*.

No contrivances are of more importance than those which may be classed under the head of furnaces; without them we should enjoy few of the necessaries and none of the comforts or luxuries of life; they comprise all kinds of fires, from those employed for mere culinary purposes, to those requisite for smelting metals, working steam-engines, &c. As to the last, though great improvements have taken place in the engines themselves, the furnaces remain nearly in the same state as Mr. Watt found them; any practical improvement in their construction must therefore be worthy of attention.

The best test of the construction of a steam-engine furnace, will be in the greatest quantity of water evaporated under a given pressure with the least quantity of fuel; from the experiments of Mr. Dalton, Count Rumford, Dr. Black, and Mr Watt, it appears that the heat generated in the combustion of one pound of coal should be sufficient to reduce from six to eight pounds of boiling hot water to steam, and if more than this weight is used, there is a proportionate quantity of heat lost.

The common house fire will, however, first claim our attention. The fire-place is generally an exact square. Its height, in large rooms, is

often very properly made less than a square, and in small rooms, particularly when the chimney is in a corner, it is rather more. In rooms from twenty to twenty-four feet square, or of equal area, it may be from four feet to four feet and a half broad; in rooms from twenty-four to thirty feet square, it may be from four and a half to five feet; and in rooms still larger, it may be extended in a similar proportion to six feet. If much beyond six feet, whatever may be the size of the room, the effect will not be good; for if the fire be proportionate, it will excite rather the idea of a furnace. Two fire-places will certainly be better than one of such immoderate dimensions. As to the effect of the form of this aperture on the draft, its breadth is not very important, provided it be not so narrow as to prevent the covings from standing with their greatest power of reflection towards the room; but the height should seldom exceed two feet six inches to the under side of the mantle. The throat should not be more than four or five inches wide; but should be contracted by a part moveable at the back, when the chimney requires sweeping. The nearer the throat is brought to the fire, the stronger the draft will be. For fire-places about three and a half feet wide in front, the flues of chimneys, above the throat, are usually made equal to about twelve inches square; and the general rule is, to make the area of the horizontal section of the flue, equal to the area of the horizontal section of the fire. If the flue were smooth and circular, this mode of proportioning its size would doubtless be found to allow it unnecessarily large. Where bends are required in a flue, they should be in a curved, and not an angular direction. High chimneys always draw better than low ones, as, in proportion to their length, the influence of the wind extends a shorter way down them. An apartment made wind-tight, by listing the doors and other contrivances, is liable to be incommoded with smoke, from the want of draft, even when the chimney is constructed in the most proper manner: a few minute holes, communicating with the exterior, will, in such cases, constitute an effectual remedy.

Another method of increasing the draft of a chimney, consists in setting the grate, if a Bath stove, eleven or twelve inches from the fender; and in cutting away the back of the chimney, so as to leave a space of two inches between it and the back of the grate. If the grate be of the common form, the sides should be filled up with brickwork. By this construction the air that passes behind the back of the grate, assisting to impel the smoke, prevents its bursting into the room. That a chimney clogged with soot will be apt to smoke, is so well known, as to require no notice here.

The grate of an *air furnace* will next claim our attention. This consists of a number of single bars, having shoulders at each end, so that when they are laid side by side, bringing their shoulders together, the interstices between the bars may be nearly equal to the breadth of the bars. The distance between the bars is here rather more than is in common use, but for producing great degrees of heat, this account will be found to answer in practice. The bars are merely laid upon two bearers placed in the brickwork at right angles to the bars; one of the bearers being loose for the purpose of sliding backwards to let all the bars fall down with the fire. Without this contrivance, after any process is finished, the fire would have to burn itself out, and it would be much more troublesome to clean the furnace when it is choaked with slag.

The height of the fire-place must be suited to the purpose to which the furnace is applied. If it is a melting furnace, the height must be such, that the fuel may be about half the width of the furnace above the top of the crucible, the latter being raised about one-fourth the width of the furnace above the grate.

A very ingenious patent furnace may now be reverted to.

The principal feature of this invention is, combining a boiler with a coke oven, for the purpose of beneficially employing the heat which radiates from the oven in generating steam or boiling water for brewing, or any other use, without the expense of fuel, and which plan also embraces in its detail convenient modes of regulating the heat communicated to the boiler, and of cutting it off altogether if required.

The patentee proposes to place an oven of about eight feet diameter under the front part of the boiler, so that the centre of the oven shall be about two feet six inches from the front of the boiler. The wall of the oven is to be straight for about eighteen inches high in the usual way, and above this the crown or arch rises about two feet six inches. In the centre of the crown a circular opening is formed of about two feet diameter, which is denominated the crater, through this the heat is intended to pass to the boiler above, the under side of which is brought as close to the top of the oven as possible. From the crater the heat proceeds through a circuitous flue round the boiler, and thence to the chimney as usual.

The span between the bottom of the boiler and the oven is to be all enclosed except about one foot square, where a fire-proof damper is to be suspended by a chain passing through the upper part of the brick work. This chain is conducted over a pulley, and carries weights as a counter-balance to the damper, which slides up and

down in grooves, for the purpose of opening or closing the square hole.

Close to the crater on the top of the oven two iron plates are placed parallel to each other. They are fastened together in front by a cross plate, and behind are worked into a low wall of two courses of brick work erected across the top of the oven. At a small distance from the plates ribs of iron are placed, on which fire-stones or fire-bricks are laid, in order to form a cover to the crater. This cover is made to slide on the plates over the crater by means of racks on the side-bars, which racks pass through the front wall to the outside of the building, and are there worked by pinions fixed on a revolving shaft turned by hand, thus the crater may be partially or entirely opened or closed.

Another flue, about six inches lower than the crown of the oven, is formed, to communicate directly with the chimney, where there are dampers to open or shut this, and also the boiler flue. In front of the oven is an iron frame, forming a door, to be lined with fire-brick. The method of lining this door is by cutting the united edges of the fire-brick in a bevel and dove-tailed form, so that one lapping over the other the whole is made fast by securing the key brick.

The patentee observes, " Now it will readily be understood, that when the cover is removed from the crater, and the damper of the oven flue shut, the heat operates upon the boiler, and raises steam; by means of the inclosure and damper, the heat may be kept longer under the boiler, where it acts more powerfully than in the flues, and when required to remove the heat from the boiler, the damper, or cover must be shut, (by means of the racks and pinions,) also the boiler damper in the chimney must be shut, and the oven damper opened. By these means, such a portion of heat may be applied to the boiler as may be required, and the operation of making good coke still go on, and the coke will repay what the coals have cost, or more. The boiler is very greatly preserved by these means, as no cold air comes in contact with it, nor coals, nor coal-rake; the smoke is also burnt: as it is well known, that to make good coke, about fifty square inches of opening in the chimney are at first sufficient, and nine at last. This small opening keeps the heat so much back in the oven, that the smoke is nearly all consumed before it can pass off."

The legal claims of the patentee are, for a method of constructing a coke oven in connection with a boiler, so as to make the heat arising from the coke answer the purpose of fuel used in the common way; and to take off the heat from the boiler, when required, without detriment

to the operation of cokeing. The advantages derived are considered to be great: in the first place the expense of fuel is repaid by the coke: secondly, the preservation of the boiler is effected in a greater degree than by the ordinary process, as no cold air is admitted to it, nor is the fuel or any other matter suffered to touch its bottom; hence it remains unimpaired, and free from the effects of sudden expansion or contraction; thirdly, the consumption of smoke in the coke oven is most complete, and, if required, a retort may be added for generating gas.

The value of a furnace materially depends on its *chimney*. The mode and cause of the ascent of smoke in a chimney may be thus explained; the air contained in the flue being heated by the fire immediately below it, becomes rarefied, and therefore lighter than the external air through which it accordingly rises, and as the heated air escapes from the top of the chimney, its place is supplied by the influx of fresh quantities of air, which, passing over the fire, becomes likewise heated, and thus a constant current is formed in the flue, which directs and carries off with it the smoke and vapour from the burning materials.*

It may now be asked, what is it that produces a smoky chimney, that is, a chimney which, instead of conveying off all the smoke, discharges a part of it into the room? The causes of this effect may be reduced to the following general cases.

Smoky chimnies in a new house, are such, frequently for want of air. The workmanship of the rooms being all good, and just out of the workman's hands, the jóints of the flooring, and of the panels of the wainscoting are all true and tight, the more so as the walls, perhaps not thoroughly dried, preserve a dampness in the air of the room

* It may be observed here, that the smoke is not, as some are apt to imagine, in its own nature specifically lighter than air, but the contrary, as may be shewn by a simple experiment. Having lit a pipe of tobacco, plunge the stem to the bottom of a decanter half filled with cold water, then putting a cloth over the bowl, blow through it, and make the smoke descend in the stem of the pipe, from the end of which it will rise in bubbles through the water, and being thus cooled, will not afterwards rise to go out through the neck of the decanter, but remain spreading itself, and resting on the surface of the water. In this case, therefore, smoke is heavier than air, and it is only when rarefied by heat that it becomes lighter. As, however, the vapour rising from a fire must always be highly rarefied, it is easy to perceive that it would be as much a miracle if smoke should not rise in a chimney, (all hindrances to its ascent being removed), as that water should refuse to run in a syphon, or to descend in a river.

which keeps the wood work swelled and close: the doors and sashes too being worked with accuracy, shut with exactness, so that the room is perfectly tight, no passage being left open for the air to enter except the key-hole, and even that is frequently closed by a little dropping shutter. In this case it is evident that there can be no regular current through the flue of the chimney, as any air escaping from its aperture would cause an exhaustion in the air of the room similar to that in the receiver of an air-pump, and therefore an equal quantity of air would rush down the flue to restore the equilibrium; accordingly the smoke, if it even ascended to the top, would be beat down again into the room. Those, therefore, who stop every crevice in a room to prevent the admission of fresh air, and yet would have their chimney carry up the smoke, require that which is inconsistent with reason, or the acknowledged principles of science. The obvious remedy in this case is, to admit more air, and the question will be, how and where this necessary quantity of air from without is to be admitted, so as to produce the least inconvenience? for if the door or window be left open, it causes a cold draft of air to the fire-place, to the great discomfort of those who sit there. Various have been the contrivances to avoid this, such as bringing in fresh air through pipes in the jambs of the chimney, which, pointing upwards, should blow the smoke up the funnel; opening passages in the funnel above to let in air for the same purpose; but these produce an effect contrary to that intended, for as it is the constant current of air passing from the room through the opening of the chimney in the flue which prevents the smoke coming out into the room, if the funnel is supplied by other means with the air it wants, and especially if that air be cold, the force of that current is diminished, and the smoke, in its efforts to enter the room, finds less resistance.

The wanted air must then indispensably be admitted into the room to supply what goes off through the opening of the chimney, and it is adviseable to make the aperture for this purpose as near the ceiling as possible, because the heated air will naturally ascend, and occupy the highest part of the room, thus causing a great difference of temperature at different heights, a defect which will be in some measure obviated by the admission of cold air near the ceiling, which, descending, will beat down and mix the air more effectually.

Another cause of smoky chimneys is too short a funnel, as, in this case, the ascending current will not always have sufficient power to direct the smoke up the flue. This defect is frequently found in low buildings, or the upper stories of high ones, and is unavoidable, for if the flue be raised high above the roof to strengthen its draft, it is

then in danger of being blown down, and crushing the roof in its fall. The remedy in this case is to contract the opening of the chimney, so as to oblige all the entering air to pass through or very near the fire, by which means it will be considerably heated, and by its great rarefraction cause a powerful draft, and compensate for the shortness of its column. The case of too short a funnel is more general than would be imagined, and often found where one would not expect it; for it is not uncommon, in ill-contrived buildings, instead of having a separate funnel for each fire-place, to bend and turn the funnel of an upper room, so as to make it enter the side of an upper flue that comes from below. By this means the funnel of the upper room is made short, of course, since its length can only be reckoned from the place where it enters the lower funnel, and that the flue is also shortened by all the distance between the entrance of the second funnel and the top of the stack; for all that part being readily supplied with air through the second flue, adds no strength to the draft, especially as that air is cold when there is no fire in the second chimney. The only easy remedy here is, to shut the opening of that flue in which there is no fire.

Another very common cause of the smoking of chimnies is, their overpowering one another. For instance, if there be two chimnies in one large room, and you make fires in both of them, you will find that the greater and stronger fire will overpower the weaker, and draw air down its funnel to supply its own demand, which air, descending in the weaker funnel, will drive down its smoke, and force it into the room. If, instead of being in one room, the two chimnies are in two different rooms communicating by a door, the case is the same whenever that door is left open The remedy is, to take care that every room have the means of supplying itself from without, with the air its chimney may require, so that no one of them may be obliged to borrow from another, nor under the necessity of lending.

Another cause of smoking is, when the tops of chimnies are commanded by higher buildings, or by a hill, so that the wind blowing over such eminences falls like water over a dam, sometimes almost perpendicularly on the tops of the chimnies that lie in its way, and beats down the smoke contained in them. The remedy commonly applied in this case is, a turn-cap, made of tin, or plate-iron, covering the chimney above, and on three sides, open on one side, turning on a spindle, and which being guided or governed by a vane, always presents its back to the wind. This method will generally be found effectual, but if not, raising the flues, where practicable, so that their

tops may be on a level with or higher than the commanding eminence, is more to be depended on.

There is another inconvenience arising from the same cause, the reverse of that last mentioned; it is where the eminence is farther from the wind than the chimney commanded. For instance, suppose the chimney of a building to be so situated as its top is below the level of the ridge of the roof, which, when the wind blows against it, forms a kind of dam against its progress. In this case, the wind being obstructed, will, like water, press and search for passages through it, and finding the top of the chimney below the top of the dam, it will force itself down that funnel in order to get through by some door or window open on the other side of the building, and if there be a fire in such chimney, its smoke is of course beat down and fills the room. The only remedy for this inconvenience is, to raise the funnel higher than the roof, supporting it, if necessary, by iron bars; for a turn-cap in this case has no effect, the dammed up air pressing down through it in whatever position the wind may have placed its opening.

Chimnies, otherwise drawing well, are made sometimes to smoke by the improper and inconvenient situation of a door. When the door and chimney are placed on the same side of a room, if the door is made to open from the chimney, it follows that, when only partly opened, a current of air is admitted, and directed across the opening of the chimney, which is apt to draw out some of the smoke.

A room that has no fire in its chimney may sometimes be filled with smoke, which is received at the top of its funnel and descends into the room. To understand this effect, it will be necessary to observe, that currents of air are frequently produced in flues, though not exposed to the influence of fire. The air contained in a funnel, being confined on every side by brick-work, which is a bad conductor of heat, will not be immediately affected by any sudden variation in the temperature of the atmosphere; and thus, while it differs in weight from the external air, an ascending or descending current will be formed in the flue. If, after a warm season, the outward air being generally cold, the empty warm funnels begin to draw strongly upwards, that is, the rarefied air contained in them begins to rise, cooler air enters to supply its place, is rarefied in its turn, and rises; and this operation continues till the funnel grows cooler, or the outer air warmer, or both, when the motion ceases. On the other hand, if, after a cold season, the outward air suddenly becomes warm, this operation is reversed. When the temperature of the atmosphere and of the flues is nearly equal, the difference of warmth in the air be-

tween day and night is sufficient to produce these currents; the air will begin to ascend the funnels as the cool of the evening comes on, and this current will continue till, perhaps, nine or ten o'clock the next morning, when it begins to be stationary, and as the heat of the day approaches, it sets downwards, and continues so till towards evening, when it again hesitates for some time, and then goes upwards constantly during the night, as before mentioned. Now, when smoke, issuing from the tops of the neighbouring chimnies, passes over the tops of the funnels which are at the time drawing downwards, as they often are in the middle part of the day, such smoke is of necessity drawn into those funnels, and descends with the air into the chamber.

Chimnies which generally draw well, do nevertheless, sometimes give smoke into a room, it being driven down by strong winds passing over the tops of their flues, though not descending from any commanding eminence. To understand this, it may be considered that the rising light air, to obtain a free issue from the funnel, must push out of its way, or oblige the air that is over it to rise. In a time of calm, or of little wind, this is done visibly; for we see the smoke that is brought up by that air rise in a column above the chimney. But when a violent current of wind passes over the top of a chimney, its particles have received enough of force to keep them in a horizontal direction, and follow each other so rapidly, that the rising light air has not strength sufficient to oblige them to quit their direction, and move upwards to permit its issue. Add to this, that some of the air may impress on that part of the inside of the funnel which is opposed to its progress, and be thence reflected downwards from side to side, driving the smoke before it into the room. The simplest and best remedy in this case, is the application of a chimney pot, which is a hollow truncated cone of earthenware placed upon the top of the flue. The intention of this contrivance is, that the wind and eddies which strike against the oblique surface of these covers may be reflected upwards instead of blowing down the chimney. The remarkable chimnies observed at Venice, in which the top of the flue is enlarged, and rounded in the shape of a funnel, seemed also intended as a remedy to this inconvenience, that the wind blowing over one of the edges into the funnel may be slanted out again on the other side by its form.

The bad construction of fire-places is another cause of smoky chimnies; and this case will lead us to the consideration of the second part of our subject, namely, the methods of increasing the heat, and diminishing the consumption of fuel; for it will be found that the improvements necessary to produce the last mentioned end will also

have a general tendency to cure smoky chimnies. On this subject the meritorious labours of Count Rumford are conspicuous, and we shall proceed to give an abridged account of his method.

In investigating the best form of a fire-place, it will be necessary to consider, first, what are the objects which ought principally to be had in view in the construction of a fire-place; and secondly, to consider how these objects can best be attained. Now the design of a chimney-fire being simply to warm a room, it is essential to contrive, so that this end shall be actually attained, and with the least possible expense of fuel, and also that the air of the room be preserved perfectly pure, and fit for respiration, and free from smoke, and all disagreeable smells.

In order to take measures with certainty for warming a room by means of an open chimney fire, it will be necessary to consider how and in what manner such a fire communicates heat to a room. This question may, perhaps, at the first view of it, appear to be superfluous and trifling; but a more careful examination of the matter will shew it to be highly deserving of the most attentive examination. To determine in what manner a room is heated by an open chimney-fire, it will be necessary, first of all, to find out under what form the heat generated in the combustion of the fuel exists, and then to see how it is communicated to those bodies which are heated by it.

In regard to the first of these subjects of inquiry, it is certain that the heat which is generated in the combustion of the fuel exists under two perfectly distinct and different forms. One part of it is combined with the smoke, vapour, and heated air which rise from the burning fuel, and goes off with them into the upper regions of the atmosphere, while the other part, which appears to be uncombined, or combined only with light, is sent off from the fire in rays in all directions. With respect to the second subject of inquiry, it is highly probable that the combined heat can only be communicated to other bodies by actual contact with the body, which are sent off by the burning fuel, it is certain that they communicate or generate heat only when and where they are stopped or absorbed. In passing through air which is transparent they certainly do not communicate any heat to it; and it seems highly probable that they do not communicate heat to solid bodies by which they are reflected.

The question which naturally presents itself here is, what proportion does the radiant heat bear to the combined heat? Though that point has not been determined with any considerable precision, it is, however, certain that the quantity of heat which goes off combined with smoke, vapour, and heated air is much more considerable, perhaps three or four times greater than that which is sent off from the

fire in rays: and yet, small as the quantity is of this radiant heat, it is the only part of the heat generated by the combustion of fuel in an open fire-place which ever is, or indeed ever can be, employed in heating a room. The whole of the combined heat escapes by the chimney, and is totally lost; and no part of it could ever be brought into a room from an open fire-place, without bringing along with it the smoke with which it is combined.

It is, therefore, of the highest importance to determine how the greatest quantity of radiant heat may be generated in the combustion of the fuel, and how the largest proportion of that quantity may be brought into the room. Now the quantity of radiant heat depends very much on the management of the fire, or upon the manner in which the fuel is consumed. When the fire burns bright much radiant heat will be sent off from it; but when it is smothered up very little will be generated, and, indeed, very little combined heat that can be employed to any useful purpose; most of the heat produced being immediately expended in giving elasticity to a thick dense black vapour of smoke, which will be seen rising from the fire, and the combustion being very incomplete, a great part of the inflammable matter of the fuel being merely rarefied and driven up the chimney, without being inflamed, the fuel will be wasted to little purpose. During this time no heat is communicated to the room, and what is still worse, the throat of the chimney being occupied merely by a dense vapour, not possessed of any considerable degree of heat, and consequently not having much elasticity, the warm air of the room finds less difficulty in forcing its way up the chimney and escaping, than when the fire burns bright: and it happens not unfrequently, especially in fire-places ill constructed, that this current of warm air from the room, which presses into the chimney, crossing upon the current of heavy smoke which rises slowly from the fire, obstructs it in its ascent, and beats it back into the room: hence it is that chimnies so often smoke when too large a quantity of fresh coal is put upon the fire.

To cause as many as possible of the rays, as they are sent off from the fire in a straight line, to come directly into the room, it will be necessary, in the first place, to bring the fire as far forward, and to leave the opening of the fire-place as wide and as high as can be done without inconvenience; and, secondly, to make the sides and back of the fire-place of such a form, and of such materials, as to cause the direct rays from the fire which strike against them, to be sent into the room by reflection in the greatest abundance.

Now, it will be found, upon examination, that the best form for the vertical sides of a fire-place, or the covings, as they are called, is

that of an upright plane, making an angle with the plane of the back of the fire-place of about 135 degrees. According to the old construction of chimnies, this angle is usually about 90 degrees, or forms a right angle; but, as in this case, the two covings are parallel to each other, it is evident they are very ill contrived for throwing into the room, by reflection, the rays from the fire which fall on them. The next improvement will be, to reduce the throat of the chimney, the immoderate size of which is a most essential fault in their construction; for, however good the formation of a fire-place may be in other respects, if the opening left for the passage of the smoke is larger than is necessary for that purpose, nothing can prevent the warm air of the room from escaping through it; and whenever this happens, there is not only an unnecessary loss of heat, but the warm air which leaves the room to go up the chimney, being replaced with cold air from without, produces those drafts of air so often complained of. But though these evils may be remedied by reducing the throat of the chimney to a proper size, yet, in doing this, several considerations will be necessary to determine its proper situation. As the smoke and hot vapour which rise from a fire naturally tend upwards, it is evident that it will be proper to place the throat of the chimney perpendicularly over the fire: but to ascertain its most advantageous distance, or how far above the burning fuel it ought to be placed, is not so easy, and requires several advantages and disadvantages to be balanced. As the smoke and hot vapour which rise in consequence of their being rarefied by heat, and made lighter than the air of the surrounding atmosphere, and as the degree of their rarefaction is in proportion to the intensity of their heat, and as this heat is greater near the fire than at a distance from it, it is clear, that the nearer the throat of a chimney is to the fire, the stronger will be what is commonly called its draft, and the less danger there will be of its smoking, or of dust coming into the room when it is stirred. But, on the other hand, when a very strong draft is occasioned by the throat of the chimney being very near the fire, it may happen that the influx of air into the fire may become so strong as to cause the fuel to be consumed too rapidly. This, however, will very seldom be found to be the case, for the throats of chimnies are in general too high.

In regard to the materials which it will be most advantageous to employ in the construction of fire-places, little difficulty will attend the determination of that point. As the object in view is to bring radiant heat into the room, it is clear that that material is best for the construction of a fire-place which reflects the most, or which absorbs the least of it, for that heat which is absorbed cannot be reflected.

Now, as bodies which absorb radiant heat are necessarily heated in consequence of that absorption; to discover which of the various materials that can be employed for constructing fire-places are best adapted for that purpose, we have only to find, by an experiment very easy to be made, what bodies acquire least heat when exposed to the direct rays of a clear fire; for those which are least heated evidently absorb the least, and consequently reflect the most radiant heat. And hence it appears, that iron, and in general metals of all kinds, which are well known to grow very hot when exposed to the rays projected of burning fuel are to be reckoned among the very worst materials that it is possible to employ in the construction of fire-places. Perhaps the best materials are fire-stone, and common bricks and mortar. These substances are fortunately very cheap, and it is not easy to say to which of the two the preference ought to be given. When bricks are used, they should be covered with a thin coating of plaster, which, when perfectly dry, should be white-washed. The fire-stone should likewise be white-washed when that is used; and every part of the fire-place which does not come into actual contact with burning fuel should be kept as white and clean as possible.

The chimney of an air furnace should be as wide as the sum of all the interstices through which the air enters the fire, allowing nothing for friction; but as this is very considerable, at least that ought to be double, so that the chimney should never be less than half that of the furnace.

The height of the chimney is the next consideration. In the present state of our knowledge we have no exact rule for the height of chimnies or furnaces. Indeed it will depend on so many circumstances, that it would be difficult to give this statement exactly; since, however, the height is limited by the friction, it will be important to avoid all those circumstances on which the friction depends. The principal of these are, the roughness and narrowness of the chimney. The velocity of the ascending air will be inversely as the width; and the friction will be as the square of the velocity. It is equally certain that the friction will be much increased if the chimney be rough in the inside, but more particularly when it is crooked, or when the air is interrupted by having to move in any other direction than that of a perpendicular one.

When, therefore, the chimney consists of an upright prism or cylinder, having its interior surface as smooth as possible, it must act to the greatest advantage possible.

If the chimney be made of brick, those sides of the bricks intended to form the interior of the chimney should be rubbed to make them

smooth, and laid with fine well-tempered fire clay, that the interior surface may be free from cavities and other inequalities.

If the chimney consists of iron lined with clay, it should be formed of lengths of about two feet each. After each of the pieces are lined and well dried, but not hard baked, the inside should be scraped or rubbed, to give them greater smoothness. By this means the height of the chimney may be increased to advantage beyond the ordinary height, since the above pieces or lengths may be fitted together and separated with the greatest facility, and the maximum of height may be easily ascertained by experiment. Another very important circumstance ought to be attended to in the construction of chimnies. The air which is heated in passing through the fire should retain its heat, if possible, till it clears the top of the chimney. Although this cannot be effectually accomplished, it may be effected as far as the non-conducting power of the materials of the chimney will admit.

The following cure for smoke in a steam-engine chimney accidentally occurred to Mr. Marsh, fire-iron maker, of the Priory, near Dudley, Worcestershire. He employs a small steam-engine to drive his lathes and other machinery for turning, grinding, and polishing his articles; the boiler of which is a round one: and having occasion to re-set it lately, he directed his boy to make a fire under it, the next morning, early: on looking out, however, at that time, and seeing no smoke issue from the chimney, as usual, he concluded that the boy had overslept himself, and accordingly went himself to the Mills. He found them at work, but still no smoke issued from the chimney: on this he sent for the bricklayer who had done the work, and questioned him on this singular effect, but he was as unable as his employer to account for it. At length, and after much puzzling, the bricklayer recollected that he had omitted to stop up two holes, of the space of a single brick each, which he had accidentally left, leading, on opposite sides, from the fire-place into the flue surrounding the boiler:—and to this, and we think justly, he attributed this fortunate result.

It appears that the flame from the fire-place, entering the flue in two opposite directions, had set fire to the smoke, and thus also converted it into flame: and although, in that neighbourhood, a little smoke is of no consequence, yet in the metropolis, and other large and populous towns, the removal of such a nuisance is an object of very considerable moment, and ought to be attempted in every possible way; and we think that this simple and easy remedy might prove effectual in a great many cases, and ought to be tried without delay.

As the buildings in London are regulated by what is commonly called the Building Act, " An Act for the further and better regulation of Buildings and Party Walls, and for the more effectual preventing mischiefs by Fire, within the cities of London and Westminster, and the Liberties thereof, and other the Parishes, Precincts, and Places within the weekly Bills of Mortality, the Parishes of St Mary-le-bone, Paddington, St. Pancras, and St. Luke at Chelsea;" which repeals and amends several former Acts for the same purpose, it may be proper to give a brief abstract of part of it. This Act, passed in the forty-second year of the reign of his late Majesty, A. D. 1774, begins by dividing all buildings into seven rates, or classes, for the purpose of subjecting them to various regulations respecting the thickness of their walls. Cap. 2. The first-rate comprehends churches, and all places of public worship, all buildings for brewing, distilling, soap making, melting of tallow, dyeing, boiling of turpentine, casting brass or iron, refining sugar, and glass making, of whatever dimensions these buildings may be, and also every warehouse and other buildings whatsoever, not being a dwelling-house, which exceeds three clear stories above the ground, exclusive of rooms in the roof, or which is of the height of thirty-one feet above the pavement of the street to the top of the coping; and every dwelling-house which, with its offices connected otherwise than by a fence wall or open passage, exceeds, when finished, the value of 850*l.* or covers more than nine squares of building on the ground floor, (each square containing 100 superficial feet). The regulations for these are, cap. 3 and 4, that all the external walls shall be built, at the foundation, of the thickness of *two* bricks and a half, or twenty-one inches and a half, thence to diminish gradually two inches and a quarter on each side to the top of the footing, which is to be nine inches high, and two inches below the surface of the paving or flooring of the cellar story; thence the wall is to be carried up two bricks, or seventeen inches and a half in thickness, to the under side of one pair of stairs floor, and thence, in the thickness of one brick and a half, or thirteen inches, up to the under side of the plate under the roof of gutter; and thence, the parapet is to be built in the thickness of one brick, or eight inches and a half, with the exception of such parts of the wall as shall be wholly of stone, which may be of the thickness of fourteen inches below the ground floor, and nine inches above. The party walls of the same buildings are to be built, at the foundation, three bricks and a half, or two feet six inches and a half in thickness; thence to di-

minish gradually four inches and a half on each side to the top of the footing, which must be one foot high, and two inches below the cellar floor; thence the wall is to be built in the thickness of two bricks and a half, or one foot nine inches and a half up to the under side of the ground floor; and thence in the thickness of two bricks, or seventeen inches and a half, up to the under side of the floor of the rooms (if any) in the roof of the highest building adjoining to such party wall; and thence of the thickness of one brick and a half in length, or thirteen inches, to the top of the wall. Cap. 5. designs the second rate of buildings, which consists of every warehouse, stable, or other building, not being a dwelling-house, that exceeds two clear stories, and does not contain more than three clear stories above ground, or which is of the height of twenty-two feet and under thirty-one feet from the pavement to the top of the coping; and also every dwelling-house which, with its offices, exceeds the value of 300*l.* and does not amount to more than 850*l.* or which covers more or less than nine squares of building. Cap. 6 and 7. The external walls of the second rate are to be built, at the foundation, two bricks thick, and diminish gradually two inches and a quarter on each side to the top of the footing, which must be nine inches high; thence to be carried up in one brick and a half thick to the under side of the one pair of stairs floor; and thence to the under side of the coping of the parapet in the thickness of one brick, stone work excepted, which may be of the thickness of nine inches above the ground floor. The party walls are to be three bricks and a half at the foundation, diminishing four inches and a half on each side to the top of the footing, which is to be nine inches high; thence the wall must be of two bricks and a half thick up to the under side of the ground floor; thence, two bricks thick up to the under side of the floor of the two pair of stairs story; and thence of the thickness of one brick and a half to the top of the wall.

Cap. 8. The third rate of buildings is designed to include every warehouse, stable, and other building, not being a dwelling-house, which exceeds one clear story, or does not contain two cl[illegible] stories above ground, or which is above thirteen feet and less [illegible]-two feet in height, from the pavement to the t[illegible]; and also every dwelling-house which, with i[illegible] value of 150*l.* and does not amount to 3[illegible] than three and a half less than [illegible] squ[illegible] 10. The external walls of [illegible]

the foundation, and to diminish two inches and a quarter on each side to the top of the footing, which must be six inches high; thence the wall is to be carried up one brick and a half thick to the under side of the ground floor, and thence one brick in thickness to the coping of the parapet. The party walls are to be three bricks thick at the foundation, diminishing four inches and a half on each side to the top of the footing, which is to be nine inches high; and thence to be built two bricks in thickness to the underside of the ground floor, and thence one brick and a half thick to the the top of such wall.

Cap. 11. The fourth rate of buildings is designed to include every warehouse, stable, or other building, not being a dwelling-house, which does not exceed one clear story above the ground, or the height of *thirteen* feet from the pavement; and every dwelling-house which, with its offices, does not exceed the value of 150*l.* or three squares and a half of building. Cap. 12 and 13. The external walls of this rate are to be similar to that of the third rate. The party walls must be two bricks thick at the foundation, diminishing two inches and a quarter on each side to the top of the footing, which must be nine inches high; thence to be carried up in one brick and a half thick to the under side of the ground floor, and thence one brick in thickness to the top of such wall.

Cap. 18. Every building, except such as are particularly included in the first or seventh rates, which is at the distance of four feet and not eight feet from any public road, and which is detached from any building not in the samê possession, sixteen feet and less than thirty feet, is declared to be of the fifth rate, and may be built on any dimensions whatever.

Cap. 19. Sixth rate only differs from the fifth, in demanding that such buildings may be eight feet distant from the street or road, and detached thirty feet from other buildings; and this rate may be built on any dimensions, and with any materials whatever.

Cap. 20. Every crane-house, or any wharf or quay, and every shamble, wind-mill, water-mill, and also every building situated without the cities af London and Westminster, and the liberties thereof, used as workshops for tanners, fellmongers, glue makers, calico printers, whitsters, whiting makers, curriers, buckram stiffeners, oil-cloth painters, wool-staplers, throwsters, parchment makers, is declared to be of the seventh rate of buildings, and may be built of any dimensions whatever. Cap. 21. Crane-houses must be built exter-

nally of stone, brick, slate, tile, oak, elm, steel, iron, or brass, and all other buildings of the seventh class may be erected of any materials whatever, but must not be covered with pitch, tar, or any inflammable composition.

Cap. 22. Every office which shall be entirely detached from the building to which it belongs, or connected therewith only by a fence, wall, or covered passage upon one or both sides, shall be deemed to be of the rate or class of building such office would be of if it did not appertain to any other building.

Cap. 24. The materials of party walls are to be of brick or stone, and no timber to be used in them, except such as be necessary for planking, bridging, or piling the foundation; and cap. 27. for templets, chains, and bond, and also the ends of girders, beams, purlins, binding or trimming joists, or other principal timbers, observing always to leave eight inches and a half of solid brick work between the ends and sides of such timbers and the timbers of adjoining buildings. Cap. 26. Party walls are to be carried up one foot six inches above the roof of the adjoining building, which shall gable against them; and to be one foot above the gutters. Cap. 29. Chimneys built in party walls are subject to the following regulations: the back of the chimney from the hearth, to twelve inches above the mantle, is to be built in thirteen inches thick in the basement story, and eight inches and a half thick in the upper stories; and those cases where chimneys are built back to back on each side of a party wall, the entire thickness of the backs is to be, in first rate houses, eighteen inches in the cellar stories, and thirteen inches in the upper stories; and in the second, third, and fourth rates, the thickness in the cellar story is to be thirteen inches, and eight inches and a half in the upper stories.

Cap. 38. Every owner of any building within the limits of this Act, who may think it necessary to repair or rebuild the party wall between his and the adjoining premises, is to give three months notice in writing to the owner of the adjoining building, appointing a survey to be made of the said wall, and naming two surveyors or able workmen on his part, and requiring also the other party to name two surveyors, to meet at an appointed place, to view and certify the state of the wall. But if the owner of the adjoining premises should neglect to appoint two on his part, according to notice, then the two surveyors first named, together with two other surveyors to be named by the party giving notice, may, within six days after the time appointed

in the notice, view the party wall, and certify, in writing under their hands, to the Court of Mayor and Aldermen, or to the justices of the peace at their next quarter or general sessions, as the case may be, the condition of the party wall, and whether the same, or any part thereof, ought to be repaired, or pulled down and rebuilt; and in case the major part of the surveyors appointed shall not, within the space of a month from the appointment, sign the certificate, then it shall be lawful for any one or more of the justices of the peace for London or Westminster, or the county of Middlesex or Surrey, as the case may be, to appoint one other surveyor to be added to the surveyors before appointed, all, or the major part of whom, are to meet, and view the party wall; and in case the major part of them shall certify the wall to be decayed or ruinous, and not sufficiently secure from fire, then, within three days from the making such certificate, a copy of it is to be delivered to the owner of the adjoining building, or affixed to the door, if it is unoccupied, and also filed with the clerk of the peace in the city, county, or liberty where such wall is situate; and the last-mentioned owners may appeal from the certificate to the next general or quarter sessions, when the justices are to summon before them one or more of the surveyors, and examine the matter upon oath, and thereupon make such orders as they think just

Cap. 41. The person at whose expense a party wall is built, shall be reimbursed by the owner of the adjoining premises who makes use of the wall, a part of the expense, in the following proportion. If the adjoining building be of the same, or a superior class to the building belonging to the person at whose expense the party wall was constructed, the owner of such adjoining building shall pay one moiety of the expense of so much of the party wall as he shall make use: but if the adjoining building be of an inferior rate, the owner shall pay a sum equal to the moiety of the expense of building a party wall as required by the Act for such class of building.

Cap. 46. Door and window frames are to be set in reveals and recesses, at least four inches from the front of the building, except the door cases of warehouses. Cap. 48. Every coping, cornice, fascia, window dressing, portico, balcony, balustrade, or other external decoration or projection whatever, is required to be made externally of brick, stone, burnt clay, or artificial stone, stucco, lead, or iron, except the cornices and dressings to shop windows, or the covered ways to any building, except from the roofs of porticos or other

entrances, but to be conveyed by metal pipes, or wooden trunks, or brick or stone funnels into drains or reservoirs. Cap. 49. No bow window or other projection shall be built next to any public street, so as to extend beyond the general line of the fronts of the houses in the said streets, except such projections as are necessary for copings, cornices, fascias, door and window dressings, or some open porticos, steps, or iron palisades; and also except shop windows, which are allowed in streets thirty feet wide or more, to project ten inches from the line of building, and five inches in streets of less width.

Cap. 53. No stack of warehouses shall contain more than thirty-five squares of building on the ground plan, except such warehouses are divided by one or more party walls into divisions of not more than thirty-five squares each, and any communications made through the party walls are to have door cases and sills of stone, and iron doors; stables are only to have twenty-five squares in one division, with the same regulations.

Cap. 55. If any building of the first, second, third, or fourth rates (except the Inns of Court or Chancery, the Royal Exchange, Companies' Halls, and except warehouses let at a rack-rent for not more than 25*l.* per year), shall be converted into two or more dwelling-houses, workshops, stables, or other buildings, which shall be in distinct tenures on the ground floor, then each such tenement shall be considered as a separate building, and be divided by party walls.

Cap. 59. No iron, tin, copper, or other pipe or funnel for conveying smoke or steam is allowed to be in front of any building, next to a public street, nor in the inside of any building, nearer than fourteen inches to any timber or other combustible material.

Cap. 62. The mayor and aldermen of the city of London, and the justices of the peace for the counties of Middlesex, Surrey, the city of Westminster, and the liberty of the Tower of London, are empowered to appoint surveyors to see the rules and regulations of this Act properly complied with: and cap. 63. before any building is begun to be erected, the master-workman is bound to give twenty-four hours notice thereof to the surveyor of the district in which the building is, who is to attend and view the building, and enforce the observance of the Act. The fees to be paid by the builder to the surveyor are, for a building of the first rate, 3*l.* 10*s.* and for an alteration or addition to the same, 1*l.* 15*s.*; for a building of the second rate, 3*l.* 3*s.* and for an alteration, 1*l.* 10*s.*; for the third rate, 2*l.* 10*s.* and 1*l.* 5*s.*; and for the fourth rate, 1*l.* 1*s.* and 15*s.*

THE

MASON'S GUIDE.

MASONRY.

Masonry is a most important branch of architecture, and consists in the art of working stones, and placing them in a level or a perpendicular direction. Hence arise as many different kinds of masonry as there are different forms and manners for laying or joining stones. Vitruvius mentions several kinds of masonry used among the ancients: three of hewed stone, *viz.* that in the form of a net, that in binding, and that called the Greek masonry; and three of unhewed stones, *viz.* that of an equal course, that of an unequal course, and that filled up in the middle; and the seventh was a composition of all the rest. The chief business of a mason is, to make the mortar; raise the walls from the foundation to the top, with the necessary retreats and perpendiculars; to form the vaults, and employ the stones as delivered to him. When the stones are large, the business of hewing or cutting them belongs to the stone-cutters, though these are frequently confounded with masons: the ornaments of sculpture are performed by carvers in stone, or sculptors.

The art of building with stone is undoubtedly of great antiquity, and its early history is difficult to trace beyond the existing remains of ancient buildings; the oldest of which are objects of wonder, chiefly on account of the difficulty of moving, with ordinary powers, the immense stones of which they are formed.

Modern masonry is confined more to the working in freestone than in marble, in the former of which these islands abound, which offer many facilities arising from the nature of its quality in reducing it to all the required shapes in modern construction. At Bath and all the Western counties they saw it by a toothed saw into smaller scantling, which is again cut by the mason with a hand-saw, and afterwards hewn by an axe, then dragged and smoothed in the same way, according to the required situation or the quality of the proposed work for which the stone is intended. The workman's tools consist of a hand-saw, similar to what is made use of by carpenters; a drag, which is commonly nothing more than a piece of an old saw. He has also his chisels and gouges, gauges and moulds for his sunk and moulded work, which are all afterwards cleaned up by the drag. In Gloucestershire, the masons often use planes for their mouldings, the stones there being more crisp and not intersected by shells, &c. which prevent their general adoption with regard to many other freestones.

Portland freestone is the common stone made use of by the masons in London, which is brought from the island of that name in blocks of almost all dimensions roughly hewn. Its hardness gives it many requisites to produce exquisite masonry. It is sawn into scantling by the friction of sharp siliceous earth and water by means of a framed plate saw of iron. It is afterwards worked by the mallet and chisel to the required form, and then rubbed to a smooth face with sand or grits by hand. Most of our public buildings are composed of this stone; and it has been the practice to make use of it in private ones for the kerbs, strings, fascias, columns, cornices, and balustrades, when all the other parts were of other materials. Internally for the floors of halls, vestibules, staircases, &c. Portland stone is decidedly the handsomest freestone known, and capable of bearing as fine an arras in moulding as marble, which is the probable reason of its preference, although many other freestones might be obtained at half the original cost, and without its great additional expense of freight and duty. The two latter, however, has risen so high of late that the Gloucestershire stone is now at the wharfs as its competitor, and is daily coming more into use, and perhaps may in a few years, in some measure, supersede it; it having been already employed in several works of consequence, in which it has been found to answer the purpose best; and as the masons get more used to it Portland stone will be discontinued, excepting for the internal work, where it will always be preferred from its superior neatness.

The granites of Cornwall and that called Dundee stone from North

Britain are now employed for all works in which great solidity and wear are required. It has been sought for and used at the several Docks, also at the new Bridges. Its excessive hardness is as much the terror of the London masons as the Gloucestershire stone is for its softness; on account of which has arisen the necessity of bringing to London the workmen as well as the stone, there not having been found persons in London who would undertake to work it. The bringing round of the granites to London and other places arose in the first instance from the necessity of finding something more solid and durable for the locks and basins of canals. The freestone of the neighbourhood having been generally found inadequate, these demands gave rise to the more multiplied working of the several quarries. Hence it is, that now all these different qualities of stone are regularly to be found in the markets, and modern masons will henceforth have the credit of effecting more lasting works than those from freestone, by a judicious blending and arrangement of all the several qualities of stones to the various purposes of strength and ornament, than they have hitherto had it in their power to do. A substantial foundation is of the first importance in masonry, without which no work can be considered as durable. However, in modern construction this vital part of a building is almost usually intrusted to the carpenter and bricklayer; the former for the purpose of piling such ground as is found inferior, soft, and marshy, and to the latter to raise the needful walls in the substructure in which little or no masonry is employed. Some architects latterly have abandoned planking, many dilapidations having been occasioned by its decay.

Planking consists in bedding strong boards of oak or fir the whole length and breadth of the proposed foundation; the former should never be less than three inches, and the latter five inches in thickness; and it would be a wise precaution to scorch them all over previously to laying them down. When the magnitude of the superstructure requires that the solid earth should be pierced, piling is had recourse to; it consists in forcing into the infirm ground piles of squared fir, oak, or any other wood, usually about nine or ten inches square, of sufficient tenacity to withstand the driving, the required length being previously ascertained by boring the ground. The ends of the piles are commonly cased, or, as it is called, shoed with pointed iron, and their upper ends or tops are cased with the same metal. The machine for forcing them consists of a frame of wood (the height of which must be regulated according to that of the pile and the power required in forcing it), framed and braced with broad and secure

ledgers and feet: at the top is a cast-iron wheel, usually about eighteen inches in diameter, the outer edge fluted to admit of a rope or chain to move in it, which rope or chain is attached to the axis of an iron cylindrical beater, which for ordinary purposes is from five to seven hundred pounds in weight. This cylinder slides sometimes in grooves in the upright frame, and often on the face of the upright. There is also a ladder attached to the machine for the purpose of adjusting the chain in the wheel, and for oiling the machine: ten, or even twenty or more men are employed, according to the nature of the soil through which the piles are to be driven, and they work the beater by raising it up and down in the frame, each taking the end of a rope for the purpose, which being all attached to the chain serve as so many handles. The labour is considered so hard, that it is not unusual, where a great many piles are to be driven, to employ double sets of men to work the beater alternately. Mr. Labelyn drove the piles of some of the foundations of Westminster Bridge by a machine worked by a horse. The machinery was considered intricate, and not practical for general purposes, and consequently it has been discontinued. The piles are usually driven as close together as they can be, and when finished, their tops are sawn off and the intervals filled up with chalk and rubble, and their tops are planked in the same manner as is described before for foundations in which planking only has been employed.

The technical terms which are of frequent occurrence may now be adverted to.

Stones which run through the thickness of a wall, in order to bind it, are called *bond stones;* in some parts of the country they obtain the name of *through stones*.

When the side or sides of a wall lean back, so that the plumb would fall within the base of the wall, the inclination is called *battering;* it is generally made about one inch in a foot.

The large stones at the base of a foundation, which project beyond the vertical surface or front of the superincumbent wall, are called *footings*.

The parts of a wall between apertures, or between an aperture and the corner, are called *piers*.

The *beds* of a stone are its upper and under surface, which are generally in a horizontal position within the wall.

Walls built with unhewn stone, with or without mortar, are called *rubble walls*. Rubble walls are of two kinds, the coursed and the uncoursed. In the coursed, the stones are hammer-dressed or axed,

and adjusted by a sizing rule, so that each row of stones forms a horizontal surface. In the uncoursed, the stones are used in a rough state, nearly as they come out of the quarry.

Walls which are faced with square stones, hewn or rubbed, and backed with rubble, stone, or brick, are called *ashlar*.

Wall-plates, are horizontal pieces of timber, commonly laid even with the interior of walls, for the ends of the joists and other timbers to rest upon.

The footings of walls ought to consist of the largest stones which can be conveniently procured. It is better to have them of a rectangular form than any other, and if not square, their largest surfaces should be laid horizontally. With this shape and disposition, they will make the greatest resistance to sinking. If the stones, intended to be employed as footings, deviate materially from a rectangular figure, when received from the quarry, they ought to be hammer-dressed; as, if they taper downwards, or rest upon angular ridges, they will be apt to give way under the weight of the superstructure. When the footings can be obtained the full breadth of the wall in one piece, they are to be preferred; but when a sufficient number of stones of this description cannot be obtained, then every alternate stone in the course may be the whole breadth, with two stones next to it, disposed like two stretchers in a nine-inch wall of Flemish brick-work. When the largest stones which can be conveniently obtained, are insufficient even for the latter arrangement, the most suitable which can be procured, must be disposed so as to break in the best manner circumstances will admit, the vertical joints in the same course, as well as those of the different courses with respect to each other. Each course, also, should be well bedded in mortar.

When bond timber will be required, the uncoursed rubble is an inconvenient mode of building, as the heights on which they are disposed must be levelled. The best kind, or coursed rubble, admits of bond timbers without difficulty, for though the different courses are not of the same height, the surface of each of them is level; but as the walls in which bond timbers are introduced, are apt to warp or even fall in case of fire, the use of them should be avoided in strong well-built walls.

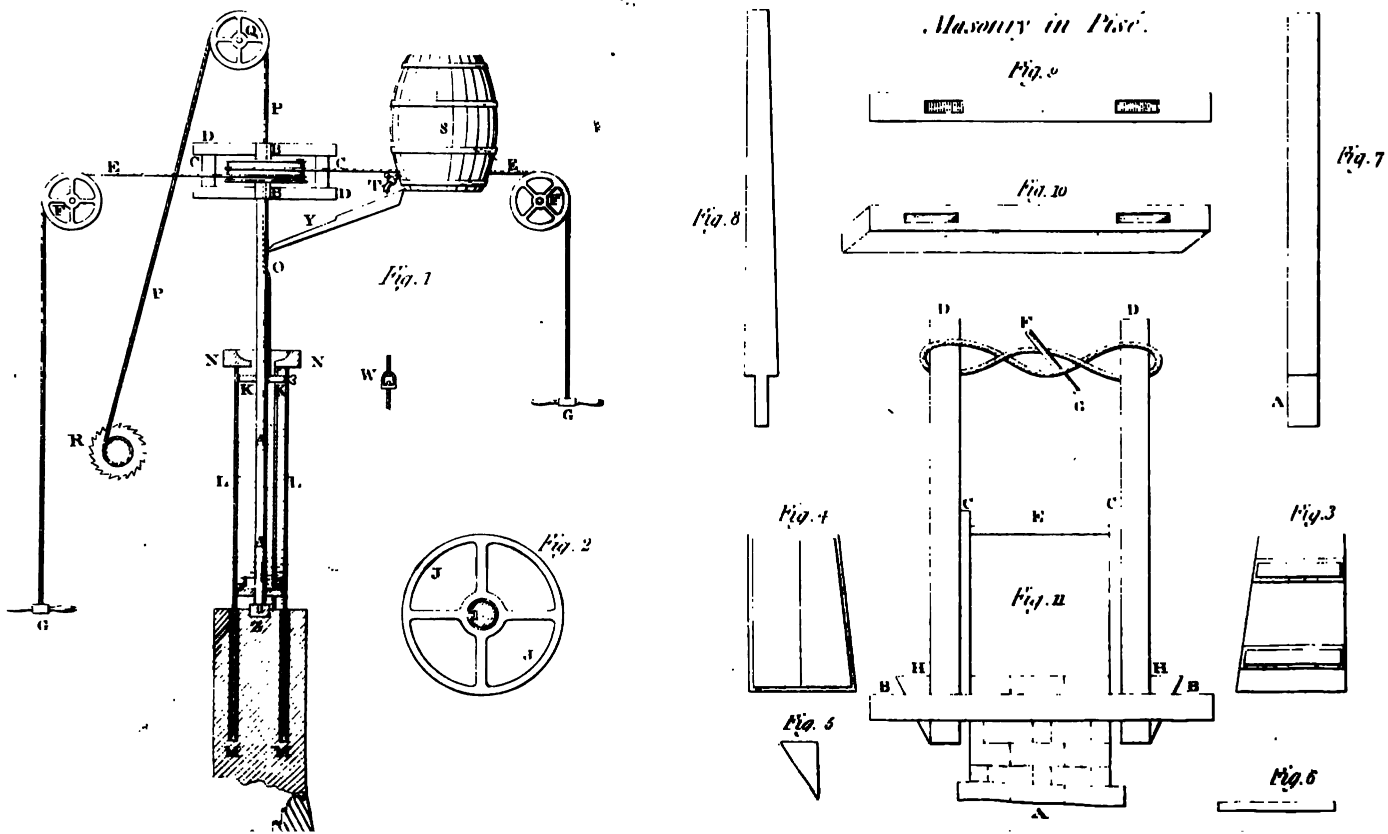
The stones of an ashlar front should have their upper and under surface correctly parallel with each other, and correctly at right angles to the face. If these surfaces be carelessly left concave, they will be apt to splinter near the edge under great pressure. On the right and left they should taper inwards, but the taper should not be continued

quite to the face, though it may reach the face within an inch or two. The ashlar stones having the form of a truncated wedge, they will, in each course, present a series of angular indentations within the wall, like the spaces between the teeth of a saw. The stones are so selected and disposed that the vertical or upright joints, and consequently the angular spaces of one course fall on the middle of the stones below. By this means the ashlar face is bonded to the rubble, brick, or rough stone of the back, and the strength of the wall much greater than if each stone was of an equal rectangular figure. Strength is also to be promoted by adopting a plan not commonly regarded, that of sorting the stones, so that in each alternate course they will extend farther into the wall than those of the course immediately above and below. In ashlar work, the bond stones, which ought frequently to be introduced, cannot like the other stones have a wedge-like form; they must be rectangular; and they produce the best effect, when so disposed in each course that they will be opposite the middle of the space between the two bond stones in the course immediately above and beneath them.

When large stone columns are made in one piece, their effect, from that circumstance alone, is very striking; but as this advantage is not always obtainable, the next object is to make the joints as few and as minute as possible, as well as to be very attentive in selecting the different stones to be combined, that the joints may not be descried at a distance, by the commencement of a different colour. From what has been said in the section on the different kinds of stone, it will be understood, that none but horizontal joints can be allowed in any shaft; all others being inconsistent with the laws of strength.

The stones proper for an intended column being procured, and the order in which they are to succeed each other being determined, the next consideration will be to ascertain the exact diameter proper for each end of every one of them. For this purpose, draw an elevation of the proposed column to the full size, divide it by lines parallel to the base, into as many heights as the column is intended to contain stones, taking care that none of the heights exceed the length that the stones will produce. The working of the stones to the diameters thus obtained then becomes easy. The ends of each stone must first be wrought so as to form exactly true and parallel planes. The two beds of a stone being thus formed, find their centres, and describe a circle on each of them. Divide these circles into the same number of equal parts, which may, for example, amount to six or eight. Draw lines across each end of the stone, so that they will pass through

PLATE IX.


Masonry in Pisé.
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11

the centre, and through the opposite divisions of the same end. The extremities of these lines are to regulate the progress of the chisel along the surface of the stone, and therefore when those of one end have been drawn, those of the other must be made in the same plane, or opposite to them respectively. The cylindrical part of the stones must be wrought with the assistance of a straight-edge; but for the swell of the column, a diminishing rule, that is, one made concave to the line of the column, must be employed. This diminishing rule will serve to plumb the stones in setting them. If it be made the whole length of the column, the heights into which the elevation of the column is divided, should be marked upon it, so that it may be applied to give each stone its proper curvature. But as the use of a long diminishing rule, when the stones are in many and short lengths, would be inconvenient, rules corresponding in length to that of the different heights, may be employed with advantage.

A very ingenious mode of sawing pipes and columns out of solid blocks of stone, suggested by Mr. Murdock, received the sanction of a patent in 1810: thus when the patentee intends to form a pipe or hollow cylinder of stone, instead of cutting out in useless scraps, or grinding to powder, the whole diameter of the bore, he cuts out a core or solid cylinder, whose outside diameter is only about half an inch less than the inside diameter of the pipe. In like manner, when he intends to form a column or solid cylinder, or a disc of stone, instead of breaking off, cutting, or chiseling away the superfluous parts of the stone, these parts are formed into a hollow cylinder, the core of which is the solid cylinder or disc required. Hence, if the stone is large enough to leave the outside parts of a proper thickness, these parts may be used as a pipe; and the core may either be used as a solid cylinder or column; or by a further operation, it may be converted into a pipe, and the cylinder cut out of it may again be converted into another pipe, which process may be continued till the core cut out is too small to be useful. The patentee accomplishes his object by the following means.

He fixes the block of stone to be perforated in an upright position, or in such a position that the axis of the bore or intended column or disc, may be perpendicular to the horizon, or nearly so.

He fixes in the centre of the intended pipe or column, a plug, or step of wood or metal, shown at Z, Fig. 1, Plate IX, having in its centre a hole, which fits the pivot of the perpendicular axis or spindle A.

The axis or spindle A, is considerably longer than the pipe or column to be formed, and of a strength proportionate to the strain

upon it. It may be either cylindrical or of any other shape, but the cylindrical form has the advantage of being most easily made straight; if cylindrical, it must contain a groove or grooves, in the direction of its length, which grooves are to receive a tongue or projecting piece from sockets that will slide up and down upon the spindle A, but are prevented by the tongue from turning round upon it; and in order that the sockets may slide steadily, whatever be the form of the section of the spindle A, it should be uniform in thickness from end to end, at least within the range of the sockets.

Upon the upper end of the spindle A, is fixed a hollow socket, B B, which fits tightly upon the spindle. The middle part of the outside of this socket is made square, or it may be of any other convenient form to receive a pully, C C, (or a small toothed wheel and pinion), by which the spindle A may be turned round; but the upper and lower parts of the socket are cylindrical, to serve as gudgeons, on which it turns round in a fixed frame, D D.

At the lower end of the spindle, near the stone to be bored, must be a wheel or cross, J J, with arms, and having a hole in the centre, which the spindle fits; and the circumference of this wheel or cross is made like a hoop, and may be two or more inches in thickness. Its diameter is a little less than that of the pipe intended to be bored, or a little more than that of the cylinder or core intended to be formed, and it fits to the inside of the tube, L L, so that the latter may slide easily over it. It is fixed fast to the spindle by a screw, pin, or key, so that it may be taken off at pleasure. This wheel, J J, for the sake of distinction, may be called the fixed or lower wheel: the plan of it is shewn at fig. 2, on a larger scale.

The upper part of the spindle is perforated longitudinally to O, a few inches below the socket, where the perforation comes out obliquely.

Upon the spindle A, and concentric with it, is a hollow cylinder or thin tube, L L, of iron, copper, brass, or any firm material, its diameter being nearly that of the pipe or cylinder to be formed, and the length exceeding, by two feet or more, the length of the proposed cylinder or pipe. To its lower edge is fixed, by means of tin solder, rivets, or screws, a hoop or ring, M M, of iron, copper, or other proper material, so much thicker than the tube, that the groove it makes in the stone may be wide enough for the tube to follow, without rubbing against the sides The hoop or ring, M M, is the saw intended to grind or cut away the stone by its lower edge; which edge is left smooth, or may be jagged like the saws used by stone-cutters. Its thickness may be varied according to the size of the tube, so as to

give the necessary strength and liberty for the tube to act, but the thinner the tube is made, preserving the necessary strength, the better.

The tube, L L, is connected with the axis or spindle, by means of a second wheel or cross, K K, called the upper wheel or cross, which is fixed by its circumference to the inside of the tube, having a hole in its centre, which fits the axis or spindle, so as to slide up and down easily upon it, without turning round, which is prevented by the form of the spindle, when that is square or triangular; or, when it is cylindrical, by its longitudinal groove, which receives from K K a feather or tongue, that only admits of a motion up and down. The tube therefore is always kept concentric with the spindle, by means of the wheels or crosses, J J and K K.

To one of the arms of the upper wheel, K K, is fixed a small cord, P P, which passes through the perforation commencing at O in the spindle, and over a pully, Q, fixed at some convenient height above it, and from that pully to a windlass, R, to which it is attached; the use of the windlass is to raise or lower the tube upon the axis or spindle, as required, even while the latter is in motion. On the upper end of the tube, are placed weights, N N, proportioned to the texture and hardness of the stone to be bored; these weights pressing downwards the saw, cause it to act upon and penetrate the stone.

The pully or pinion, C C, is fixed upon the socket which receives the upper end of the spindle; the diameter of it, the patentee generally makes about twice the diameter of the tube, L L, or of the inside of the pipe to be bored. When the apparatus is put in motion by men's force, a pully, as shown in the plate, will be most convenient. A rope, E E, is wound round this pully, the ends of which pass over two other pullies, F F, one of which is fixed at a convenient distance on each side of the spindle. The ends of this rope then turn downwards, and having handles, G G, fixed to them, are pulled alternately by a man at each handle, so as to give the pully and spindle a reciprocating or alternate rotative motion.

At a convenient distance, on one side, is placed a tub or cistern, S, containing water, with its bottom as high as the pully of the spindle. From this cistern, by the cock, T, is discharged a sufficient stream of water, into a trough or conductor, Y, placed in an inclined position, and with one end reaching nearly to the spindle. Sand is, from time to time, sprinkled into this trough, and is by the water carried down into the tube, which being set in motion, the saw at its lower end, assisted by the sand and water, grinds away the stone, and forms a circular groove, concentric with the axis of the spindle, and the tube

being constantly pressed downwards, the groove becomes deeper, and the water accumulates in the inside of the tube, until it can force its way under the saw, and escape by the outer side of the groove. In its passage it carries the sand along with it, which continues the action of the saw upon the stone; and when the sand has done its office, it is carried away by the water, in the form of mud or sludge, so that the action is continued without interruption, as long as the motion of the tube is maintained. If the motion be stopped for any time, while the tube is in the position for working, it will be found difficult to free it again; when the work is stopped, it should therefore be raised up, by means of the windlass, R, and the cord, P P, which passes through the central perforation of the axis or spindle; the water-cock may at the same time be either stopped or not, as convenient; but if stopped, it must of course be again opened when the work is recommenced: in this manner is the process conducted, till the pipe, column, or disc intended to be formed, is completed.

By the means above described, the dead sand and sludge are removed as they are formed, and the necessity there would otherwise be of raising up the tube from time to time, in order to take out the sand and sludge by separate operations, is avoided. An essential part of the process consists in always maintaining a pillar of water within the tube, sufficient to force its way under the lower edge of the saw, and to carry the sand with it; without this, the tube would require to be frequently removed, and it would be almost impossible for the saw to penetrate beyond a few feet in depth, in any reasonable time.

When the depth of the bore, or length of the pipe to be formed, exceeds six or seven feet, a readier outlet for the water, sand, and sludge may be made, in common work at least, by boring one or more holes, suppose about the diameter of an inch, in the sides of the pipe, and when the pipe is finished, these holes may be stopped up.

When the apparatus is put in motion by any other power than that of men, instead of the pully C C, the patentee sometimes fixes a small toothed wheel or pinion upon the socket B B, which wheel or pinion is acted upon by a reciprocating toothed wheel, or by a reciprocating rack; or he retains the pully and cord, as if it were to be acted upon by men, and affixes a sufficient weight or spring, in the place of one of the handles, G, and causes the power to pull the other end of the rope, by means of a crank, or other equivalent contrivance.

When the outside of a pipe is to be rounded, as from a rough block, the operation may commence by employing the tube, L L, and

a saw, of sufficient diameter to leave the stone strong enough round the intended pipe, and proceed with them, as before described, until they have gone down through the whole depth of the stone, leaving within them a cylinder, of a proper size for the intended pipe. Then remove the tube and saw first used, and use a tube and saw adapted to the intended bore of the pipe, and work them through: one pipe, of a regular shape both within and without, will then be formed; and it is obvious that the core remaining may, by the use of still smaller tubes and saws, be wholly converted into pipes, of sizes differing from each other by the thickness of the groove or kerf of the saw.

In some cases it may be convenient, to turn the tube and saw with a uniform rotative motion, always in one direction; but with a motion of this sort, the work will not proceed so rapidly, as by the alternate motion above directed; where, however, a rotative motion in one direction is used, it will be found advisable to fix a swivel in the small cord, P P, as that represented at W, to prevent its over twisting; and this again requires the pully Q to be placed higher up, so as to give room to place the swivel between it and the pully, C C, to prevent its interfering with the swivel.

Having thus briefly examined the technicalities of the art, and the mode of raising walls and forming columns, we may direct the reader's attention to a branch of building very nearly connected with the subject, we mean that of masonry in Pisé, and which, from its great simplicity, must now claim attention.

Building in *Pisé* is an art entitled to considerable attention, arising from out of its economy as well as its general utility. Every country abounds with the materials from which it may be formed, and in all nations it may be had recourse to for the building of useful as well as ornamental dwellings with fewer tools and with less of mechanism and machinery than is required for any kind of building now practised. In the year 1791, a work was published in Paris, by M. Francois Cointereax, containing an account of a method of building strong and durable walls and houses with no other materials than earth, and which has been practised for ages in the province of Lyons, though little known to the rest of France or any other part of Europe. It appeared to be attended with so many advantages, that many gentlemen in this country who employ their leisure in the study of rural economy, were induced to make trial of its efficacy, and the event of their experiments has been of a nature to make them wish by all possible means to extend the knowledge and practice of so beneficial an art. With a view to promote this desirable end, the account con-

tained in the following pages has been extracted from the French work, and it will be found to contain every necessary instruction required by those into whose hands the original work may not have fallen, or who being unacquainted with the language may have been prevented from consulting it. The appearance of those wretched hovels which are built with mud in some parts of England, will perhaps dispose many persons to doubt the strength and durability of houses which are composed of no other materials than earth. The French author says, "the possibility of raising the walls of houses two or even three stories high, with earth only, which will sustain floors loaded with the heaviest weights, and of building the largest manufactories in this manner, may astonish every one who has not been an eye-witness of such things." But it is hoped that a description of the manner of building will sufficiently explain the reason of its superiority.

The word pisé, or *en pisé*, is a technical term made use of in the country where the work about to be described is in common practice, and it has been retained because it cannot be rendered by any adequate word in the English language. Pisé is a very simple manner of operation; it is merely by compressing earth in moulds or cases that we may arrive at building houses of any size and height. This art, though until very lately confined to the single province of Lyons, in France, was known and practised at a very early period of antiquity, as appears from a passage in Pliny's Natural History, lib. 34, c. 14, which is exactly a description of the manner of building. M. Goiffon, who published a treatise on Pisé in 1772, is of opinion that the art was practised by the Romans, and by them introduced into France; and the Abbé Rozier, in his Journal de Physique, says, "that he has discovered some traces of it in Catalonia," so that Spain, like France, has a single province in which this ancient manner of building has been preserved. The art, however, will deserve to be introduced into more general use. The cheapness of the materials which it requires, and the great saving which it admits of, must recommend it in all places and on all occasions. But the French author says, "that it will be particularly useful in hilly countries, where carriage is difficult and sometimes impracticable; and for farm-buildings, which, as they must be made of considerable extent, are usually very expensive without yielding any adequate return. All earths are fit for the purpose when they have not the lightness of poor lands nor the stiffness of clay; secondly, all earths fit for vegetation; thirdly, brick-earth; but these, if they are used alone are apt to crack, owing

to the quantity of moisture which they contain. This, however, does not hinder persons who understand the business from using them to a good effect. Fourthly, strong earths with a mixture of small gravel, which, for that reason, cannot serve for making either bricks, tiles, or pottery. These gravelly earths are very useful, the best pisé is made of them. These general principles may suffice without over-burdening the memory of the reader, and from the following remarks may be known what earths are fittest to be employed by themselves—when those have been described, it will remain to point out such as must be mixed with others, in order that they may acquire the necessary quality. The following appearances indicate that the earth in which they are found are fit for building; for instance, when a pick-axe, spade, or plough brings up large lumps of earth at a time; when arable land lies in clods or lumps: when field-mice have made themselves subterraneous passages in the earth, all these are favourable signs. When the roads of a village have been worn away by the water continually running over and through them are lower than the contiguous lands, and the sides of those roads support themselves almost upright, it is a sure mark that the pisé may be executed in that village. One may also discover the fitness of the soil by trying to break with one's fingers the little clods of earth in the roads and find a difficulty in so doing, or by observing the ruts of the road in which the cart-wheels make a sort of pisé by their pressure; whenever there are deep ruts in a road one may be sure of finding abundance of proper earth. Such earth is found at the bottom of slopes of low lands that are cultivated, because every year the rain brings down the fat or good earth. It is frequently found on the banks of rivers, but above all it is found at the foot of hills where vines are planted. In digging trenches and cellars for building, it generally happens that what comes out of them is fit for the purpose.

As it may sometimes happen that earth of a proper quality is not to be found on the spot where it is intended to build, it becomes of importance to attend to the method of mixing earths; for though the earth which is near at hand may not of itself be proper, it is very probable that it may be rendered so by the mixture of a small quantity of another earth fetched from a distance. The principle on which the mixture must be made is very simple; strong earths must be tempered with light; those in which clay predominates with others that are composed more of chalk and sand; and those of a rich glutinous substance, with others of a poor and barren nature. The degree in which these qualities of the earths prevail, must determine the pro-

portions of the mixture, which it is impossible here to point out for every particular case, but which may be learnt by a little practice. It would not be amiss to mix with the earth some small pebbles, gravel, rubbish of mortar, or in short any small mineral substance; but none of the animal or vegetable kind must be admitted. Such hard substances bind the earth firmly between them, and being pressed in all directions contribute very much to the solidity of the whole, so that well worked earth in which there is an admixture of gravel becomes so hard in about two years time, that a chisel must be applied to break it as though it were freestone.

First experiment to ascertain the qualities of earth proper for making pisé.—Take a wooden tub or pail without a bottom, dig a hole in the ground of a court or garden, and at the bottom of that hole fix a piece of stone flat and level, place your tub upon the stone, filling round it the earth that has been dug out to make the hole, and ram it well that the tub may be enclosed to prevent its bursting; then ram into the tub the earth you mean to try, putting in at each time about the thickness of three or four finger's breadth; when this is well rammed, add as much more and ram it in the same manner, and so for the third and fourth, &c. till the earth is raised above the brim. This superfluous earth must be scraped off extremely smooth, and rendered as even as the under part will be which lies on the stone. Loosen with a spade the earth round the tub, and you will then be able to take it out, and with it the compressed earth that it contains; then turn the tub upside down, and if it be wider at the top than at the bottom, as such vessels usually are, the pisé will easily come out; but if it should happen to stick let it dry in the air twenty-four hours, you will then find the earth is loose enough to fall out of itself. You must be careful to cover this lump of pisé with a little board, for though a shower of rain falling in an oblique direction will not injure it, yet it may be a little damaged if the rain fall perpendicular, and especially if it receive it so for any length of time. Leave the lump exposed to the air, only covered over with a board or flat stone; and if it continue without cracking or crumbling, and increases daily in density and compactness as its natural moisture decreases by evaporation, you may be sure that the earth is fit for building. But you must remember that it is necessary that the earth employed should be taken from a little below the surface of the ground, in order that it may be neither too dry nor too wet. It must be observed also, that if the earth is not well pressed around the outside of the tub before it is filled; though the hoops were of iron they would burst, so great is

the pressure of the beaten earth against the mould, of whatever size it may be.

Second experiment.—This trial may be made in the house: having brought from the field the earth you want to try, press it in a stone mortar with a pestle of wood, brass, or iron (the latter is best), or with a hammer; fill the mortar above its edge, and then with a large knife or some other instrument take off the superabundant earth even with the brim; if you then find that the earth will not quit the mortar you must expose it to the sun or near a fire, and when it is sufficiently dry it may be taken out without difficulty by turning the mortar upside down on a flat stone or on the floor. It will have the shape of the mortar, and if exposed as above directed will shew the qualities of the earth.

In building en pisé and preparing the earth all the operations are very simple and easy; there is nothing to be done but to dig up the earth with a pick-axe, break the clods with a shovel so as to divide it well, and then lay it in a heap, which is very necessary; because, as the labourers throw up that heap the lumps of earth and large stones will roll to the bottom, when another man may break them or draw them away with a rake. It must be observed, that there should be an interval of about an inch and a quarter between the teeth of the rake, so that the stones and pebbles of the size of a walnut or something more may escape, and that it may draw off only the largest. If the earth that has been dug has not the proper quality, which is seldom the case, and it be necessary to fetch some better from a distance, then the mixture must be made in this manner; one man must throw one shovelful of the best sort, while the others throw five or six of the inferior sort on the heap, and so more or less according to the proportion which has been previously ascertained. No more earth should be prepared than the men can work in one day, or a little more, that they may not be in want when about the building; but if rain be expected you must have at hand either planks, mats, or old cloths to lay over the heap of earth, so that the rain may not wet it, and then as soon as the rain is over the men may resume their work, which, without this precaution, must be delayed; for it must be remembered that the earth cannot be used when it is either too dry or too wet, and therefore if the rain should wet it after it has been prepared, the men will be obliged to wait till it has recovered its proper consistency; a delay which would be equally disadvantageous to them and their employer. When the earth has been soaked by rain, instead of suffering compression it becomes mud in the moulds, and even

though it be but a little too moist it cannot be worked; it swells under the blows of the rammer, and a stroke in one place makes it rise in another. When this is the case it is better to stop the work, for the men find so much difficulty that it is not worth while to proceed. But there is not the same necessity of discontinuing the work when the earth is too dry, for it is easy to give it the necessary degree of moisture in such a case; to do which it should be sprinkled with a watering-pot, and afterwards well mixed up together, it will then be fit for use. It has already been observed that no vegetable substance should be left in the earth, therefore, in digging, as well as laying the earth in a heap, great care should be taken to pick out all sprigs and herbs, all bits of straw or hay, chips or shavings of wood, and, in general, every thing that can rot or suffer a change in the earth.

The implements employed in the erection of Pisé buildings are few, and easy of construction. Fig. 1, Plate IX, represents the head of the mould seen without side. Fig. 4, the other face seen within side. Fig. 5, the wedges to secure the upright post in the joists, fig. 9, 10. Fig. 6, a round piece of wood, called the wall-gauge. Fig. 7, one of the upright posts seen on its flat side, with its tenon to enter the mortise in the joists. Fig. 8, the same on its back, also with its tenon. Fig. 9, a joist, in which the mortise is made to receive the tenon of the upright, and wedges seen flatways. Fig. 10, the same, with its side and bottoms seen. Fig. 11, the mould for the Pisé wall put together, in which its various parts are connected.

The openings for the doors and windows must be left at the time of building the walls. This may be done by placing within the mould one or two of the heads of the mould, as may be found necessary, wherever the wall is to terminate and the opening to commence. They should be made sloping a little in order to leave room for the frames and sashes. The exterior decorations of the windows and doors are usually made by the rich of stone or bricks, and by the poor of wood, which latter have a bad effect on the appearance of the house, as wood will never unite well with pisé-work; and, notwithstanding the greatest precautions, the exterior covering will break and fall off the wood, whereas stone or brick work unite perfectly with the pisé, and retain their plaster, and, of course, their paint, of which it forms the ground. The chimney-pieces are laid and united with the walls in the same manner as in a common building, and the flues are also very firmly connected with them, being made of brick work. But a very particular advantage is, that the apartments may be very handsomely finished without making any jaumbs to the inside doors, either

of stone or wood. The facings of wood to the earthen wall will render jaumbs unnecessary, and why should the expense of any other finishing be incurred, when the doors may be hung on the grounds or wainscot of the apartments?

Beaten or compressed earth is used in many different sorts of work. The ancients employed it in making their rough walls; the Spaniards, the French, and others, for some of the floors of their apartments. The intent of the ancient architects, when they recommended the beating of cement and other compositions used in buildings, was to prevent them from shrinking or cracking, and it is employed for the same purpose in buildings which are made of earth. The beating, by repeated strokes, forces out from the earth the superfluous water which it contained, and closely unites all the particles together, by which means the natural attraction of the particles is made to operate, as it is by other causes in the fermentation of stones. Hence arises the increasing of strength and the astonishing durability which houses of this kind are found to possess.

In one single day three courses, of about three feet in height each, may be raised one over another, so that a wall of earth of about eight or nine feet, or one story high, may be raised in one day. Experience has proved, that as soon as the builders have raised their walls to a proper height for the flooring, the heaviest beams and rafters may without danger be placed on the walls thus newly made, and that the thickest timber of a roof may be placed on the gables of pisé the very instant they are completed.

To make good walls of pisé it is not sufficient that the earth be well beaten, we must also learn to unite them well together. In houses of brick or stone, to consolidate their parts they make use of angles and binders of free-stone; and of iron-braces and cramp-irons, which are very expensive; but here the binders cost very little, consisting only of thin pieces of wood, a few cramps and nails, and these are found sufficient to give the greatest solidity to buildings of pisé. The first course being laid on the front and inner walls of a house, we begin with the second, and if the inferior course has been directed a certain height, it must for this second be directed as much higher; but before this second course is began, lay at the bottom of the mould a board about five or six feet long, resting on the opposite angle, and extending lengthwise; this board must be rough as the sawyers have left it, and about an inch thick, and in breadth about eight, nine, or ten inches, so that there may remain on each

side four or five inches of the earth of the wall, which is eighteen inches in thickness; by this means the board will be entirely concealed in the body of the pisé, and when there placed, neither the air nor damp can reach it, and, of course, there is no danger of its rotting. This has been often proved by experience, as in taking down old houses of pisé such boards have always been found perfectly sound, and many that have not lost the colour of new wood. It is easy to conceive how much this board will equalize the pressure of the work raised above it, and will also contribute to bind together the two lengths, and to strengthen the extreme angle; but this is not all, it is useful (particularly when the earth is not of a very good quality) to put ends of planks into the pisé after it has been rammed to about half the height of the mould. These ends of planks should be only ten or eleven inches long, to leave, as before, a few inches of earth on each side of the wall; if it is eighteen inches thick, they should be laid crosswise (as the plank before mentioned is laid lengthwise) over the whole course, at the distance of about two feet from one another, and will serve to equalize the pressure of the upper parts of the work on the lower course of the pisé. The boards mentioned need only be placed at the angles of exterior walls, and in those parts where the partition-wall joins to those of the exterior wall. The same directions that have been here given for the second course must be observed at each succeeding course up to the roof. By these means the reader will perceive that an innumerable quantity of holders or binders will be formed, which sometimes draw to the right, sometimes to the left, of the angles, and which powerfully unite the front walls with those of the partitions, the several parts deriving mutual support from one another, and the whole being rendered compact and solid. Hence these houses, made of earth alone, are able to resist the violence of the highest winds, storms, and tempests. The height of each story being known, boards of three or four feet in length should be placed before-hand in the pisé, in those places where the beams are to be fixed; and as soon as the mould no longer occupies that place the beams may be laid on for each story, and the pisé may be continued as high as the place on which you intend to erect the roof.

With respect to walls for enclosures of parks, gardens, yards, &c. the mould must be fixed in an angle, or against a building, if the wall is to reach so far, and the workmen must proceed from thence to the other extremity of the wall, and when they have fixed the first

course they must raise the mould to make the second, returning to the place where they began the first. But when a very great enclosure is to be made, as, for instance, a park wall, then, for the sake of speed, it is necessary to set several moulds and men to work. In such a case, a mould should be placed at each end, and the number of men be double; they will work at the same time, and meet in the middle of the wall, where they will close the first course, after which, each set of men raise their mould to make their second course, and both setting out again for the middle, continue working in opposite directions towards the ends where they first began. Besides the advantages of strength and cheapness this method of building possesses that of speed in the execution. That the reader may know the time that is required for building a house or an enclosure, he need only be told that a mason used to the work can, with the help of his labourer, when the earth lies near him, build in one day six feet square of the pisé. If two men can build in one day six feet square, it is evident that six men, which is the necessary number to work the mould (viz. three in the mould and three to dig and prepare the earth), will build, in the course of sixteen days, or three weeks at most, a house estimated to contain two hundred and eighty-eight feet square of wall. A very short space of time therefore is sufficient for a man to build himself a solid and lasting habitation. These facts, which have been proved by numberless instances, afford a proposition by which every one may determine the time that his house or wall will take in building, having first ascertained the number of feet it will contain.—Thus, if he wishes to have a wall five hundred and forty feet long, and six feet high, it will be finished in one month with one single mould and six men, and if he doubles both moulds and men it will be done in fifteen days. These are simple but necessary instructions, for they will prevent the inconvenience to which many are exposed from having the completion of their building protracted beyond the time that they originally expected. All persons who wish to build may hence contract with a builder that the work shall be finished on such a day, or that he shall indemnify them for all the losses which they may incur from his failure in the making good of his engagement.

In this way houses may be built, which are strong, healthy, and very cheap; and which will last a great length of time, as the author from whom we principally quote says, he had pulled down some of them, which, from the title deeds in the possession of the proprietors, appeared to be 165 years old, though they had been ill

kept in repair. The rich traders of Lyons have, he observes, no other way of building their country-houses. An outside covering of painting in fresco, which is attended with very little expense, conceals from the eye of the spectator the nature of the building, and is a handsome ornament to the house. That method of painting has more freshness and brilliancy than any other, because water does not impair the colours. No size, oil, or expense is required, manual labour is almost all it costs, either to the rich or poor. Any person may make his house look as splendid as he pleases for a few pence laid out in red or yellow ochre, or in other mineral colours. And he adds, that strangers, who have sailed upon the Rhone, probably never suspected that those beautiful houses which they saw rising on the hills around them, were built of nothing but earth; nay, many persons have dwelt for a considerable time in such houses, without ever being aware of their singular construction. Farmers in that country generally have them simply whitewashed, but others, who have a greater taste for ornament, add pilasters, window-cases, pannels, and decorations of various kinds.

Besides, it is suggested that there is every reason for introducing this method into all parts of the kingdom; whether we consider the credit of the nation as concerned in the neatness of its villages, the great saving of wood which it will occasion, and the consequent security from fire, or the health of the inhabitants, to which it will greatly contribute, as such houses are never liable to the extremes of heat or cold. It is attended with many other circumstances that are advantageous to the state, as well as to individuals. It saves both time and labour in building, and the houses may be inhabited almost immediately after they are finished; for which latter purpose the holes made for the joists should not be closed up directly, for the air, if suffered to circulate through them, will dry the walls more speedily. And the durability of this sort of building is fully shown by the statement of the Rev. Mr. Jancour, who resided at Montbrison, in France, where, he says, the church was the most remarkable in this style of building; it is about eighty feet long, forty feet broad, and fifty feet high; the walls built in *pisé* eighteen inches thick, and *crépé*, or rough cast on the outside with lime and sand. Soon after his arrival, the church, by some accident, was destroyed by fire, and remained unroofed for about a twelvemonth, exposed to rains and frost. As it was suspected that the walls had sustained much damage, either by fire or the inclemency of the season, and might fall down,

it was determined to throw them down partially, and leave only the lower parts standing; but even this was not done, he adds, without much difficulty, such was the firmness and hardness these walls had acquired, the church having stood above eighty years; and all the repairs required, were only to give it, on the outside, every twelve or fifteen years, a new coating of rough-cast. And it may be further remarked, that besides the advantages of strength and cheapness, this method of building possesses that of speed in the execution.

In regard to the outside covering of plaster, which is proper for rammed earth or pisé walls, it is quite different from that which is made use of on any other walls; it is necessary, too, to take a proper time for laying it on. When a house of this sort is begun in February, and completed in April, the covering may be laid on in the autumn, that is to say, five or six months after it is finished; or if it is finished in the beginning of November (at which time the masons generally give over working) it may be laid on in the spring. In this interval the walls will be sufficiently dried; but it must not be imagined that it is the drought or cold that extracts the moisture from an earthen wall; it is only the air, which is of itself sufficient either in summer or winter, to dry a pisé or rammed earth wall thoroughly. If the plaster be laid over them before the dampness is entirely gone, it must be expected that the sweat of the walls will cast it off.

But in order to prepare the walls for plastering, they should be indented with the point of a hammer, or hatchet, without being afraid of spoiling the surface left by the mould; all those little dents must be made as close as possible to each other, and cut in, from top to bottom, so that every hole may have a little rest in the inferior part, which will serve to retain and support the plaster. And to do it the masons must make a small scaffold in the holes which the joists of the mould have left. This scaffold may be made in a few minutes, and when, with the assistance of it, they have indented the upper parts of the house, they must run a stiff brush over the indented surface, to remove all dust or loose earth. The walls, when thus prepared, may receive the plastering; but it should be observed that there are two kinds of plaster that may be used in the pisé; rough-cast, and stuccoing. Rough-cast consists of a small quantity of mortar, diluted with water in a tub, to which a trowel of pure lime is added, so as to make it about the thickness of cream. Stucco is nothing more than poor mortar, which the labourers make

up in a clean place near the lime-pit; and carry it to the masons on the scaffold.

Besides, for the purpose of rough-casting, one workman and his labourer are sufficient; the workman only sprinkles with a brush the wall he has indented, swept, and prepared; after that he dips another brush, made of bits of reed, box, &c. into the tub which contains the rough-cast, and throws with this brush the rough-cast against the wall; when he has covered, with as much equality as possible, so much of the wall as is within his reach, he lowers his scaffold, and stops up the holes of the joists with stones, or old plaster, &c. does as before, and continues lowering his scaffold in the same manner till he comes to the bottom of the house. This rough-cast, which is attended with so little trouble and expense, is notwithstanding the best cover that can be made for pisé, or rammed earth walls, and for all other constructions; it contributes to preserve the buildings, and though not beautiful, has the recommendation of being attainable by people in moderate circumstances. It is the peculiar advantage of these buildings that all the materials they require are cheap, and all the workmanship simple and easy to be performed.

But in regard to the process of stuccoing it is very different; two workmen and two labourers are requisite, the two workmen being on the scaffold, and one of the labourers making up the mortar while the other carries it with water, and serves the workmen. One of the workmen holds in his right hand a trowel, and in the other a brush, with which he sprinkles the wall, haying before hand indented and swept it; after that, he lays on a few trowels full of stucco, which he spreads as much as possible with the same trowel, and then he lays on more, and thus continues his work. The second workman has also in his left hand a brush, and in his right hand a small wood float; he sprinkles water over the mortar that his partner has spread, and rubs over that part he has wetted with his wood float. Thus the first workman lays on the plaster, and advances gradually, the second follows and polishes; one labourer makes up the stucco, the other carries it, and serves the workmen. By this process the smoothest, finest, and cheapest plastering is made. And at the same time that the plaster is laid on, it may also be whitened by the use of lime alone, which is also an object of economy, since it saves white lead, &c. For this purpose dilute lime in a tub of very clear water, and let a labourer take some of it in a pot, and carry it to the workmen, who must lay it on with a brush; this, as well as all other colours, adheres

to the plaster, and never falls, although it is used with water only, without size or oil. This is to be attributed to the precaution of laying on the colour whilst the plaster is still wet; as it grows dry, it incorporates the mineral colours with its own substance, and makes them last as long as itself. This is on the principle of fresco colouring or painting, which is very neat.

And it is added, that the lime is of very general utility; it is used in building, in plastering, and in white-washing; and it will appear that for painting also it may be employed with advantage. Those who intend to build, therefore, ought always to have a store of it by them, and it should be slaked a long time before it is used, to prevent crevices and blisters, which, without this precaution, will arise in the plaster, and give it so disagreeable an appearance, that it will be necessary to do the work over again. The reason of it is this, there will always remain in the lime some particles that have not been slaked in the pit; all the stones are not entirely reduced to lime in the kiln, and those stones will resist the action of the water for a time, and will burst from the plaster after it has been laid, leaving the crevices above mentioned. This inconvenience will not happen if the lime, after being slaked, is left to stand some time before it is used. Indeed it will not be amiss to let it lie by a whole year, or longer, when it can be done with convenience. Besides this, it is observed on the painting in fresco of the outside covering, that that kind of painting which is known by this name, is the most beautiful and cheapest of any, and it is that which the author recommends for the decoration of pisé, or rammed earth buildings. The most celebrated painters were very partial to it, and Rome furnishes many excellent models, which should engage us to restore it from that neglect and disuse into which it has, without reason, been suffered to fall. And that whoever wishes to have his house painted in fresco, must have a painter ready, and place him on the scaffold with the workmen. The latter lay on the mortar, as before directed, and are attentive to spread it very even to receive the paint. When they have finished one part, they suspend their work, to give the painter time to do his; for if they continued working on, the painter, who cannot go on so fast as they, would find the mortar too dry, and the colours would not incorporate with it. It is absolutely necessary that the plasterer's work should be subordinate to that of the painter; it is sometimes so arranged, that the latter work while the former are gone to their meals; and when in his turn he retires from work, he traces out the part that the plasterers are to

cover during his absence, foreseeing how much he shall be able to paint in the course of the day. All these precautions are taken to prevent the too speedy drying of the mortar, and to seize the proper time to lay on the colours while it is fresh.

And in order to make the colour meant to be given to a country house, dilute in a large tub a sufficient quantity of lime which has been slaked a long time; and also dilute in another tub or pot some ochre, either yellow, red, or any other mineral colour, but always in very clear water; after which, pour a little of the colour into the large tub, and stir it about with a stick, so as to mix it well with the lime; take some of the colour on a brush, and try it on a board or wall; if it is too deep or too light, add fresh lime or colour from the tub, and by repeated trials bring it to the tint that is wished to be given to the house. The colour being made for the body of the house, the frames of the doors and the windows are next to be considered, and a new colour chosen to distinguish them from the rest of the front. If the body of the house is painted yellow, or of a pale red, the angles and frames may be white or blue; if it is grey, they may be yellow or deep red; and in all cases it will be a very easy matter to find the most suitable colours. It is added, that the plasterers are equal to painting the fronts of houses in a common way; but when builders or proprietors wish to have them decorated in a superior manner, they must call in a painter whose business it is to do it. The writer asserts that these paintings in fresco are more lively and more brilliant than any other; because the colours are not deadened by size or oil, which do not enter into their composition; their effect is surprising, and may be had at a little expense. And in concluding, it is remarked that the plaster proper to serve as a ground for fresco painting or colouring, is made of one part lime, and three parts clean, sharp, washed sand; also that this sort of painting has lately been executed with great success at Woburn Abbey, and some other places in this country. It is not very usual, it is observed, to slake the lime in this country so long before it is wanted; but it is an excellent practice, especially if it be wood-burnt.

In short, this method of building seems, from its cheapness and durability, and the readiness with which it is executed, to deserve the attention of the proprietors of lands in this kingdom, as the means of raising comfortable houses for their labourers and cottagers, which from the increased prices of the usual sorts of building materials, are now become seriously expensive in providing.

Some different kinds of buildings of these earthy materials may be seen at Woburn Abbey, the seat of the Duke of Bedford, and in some other places.

Having in the preceeding pages examined some of the more simple and elementary branches of the art of masonry, we may now proceed to notice the mode of constructing an arch; still, however, leaving the mathematical part of the subject to that portion of our work exclusively devoted to bridge building.

Arching is that in which the modern masons have most excelled the ancient. In Greece, if it were understood, it was but little practised; but there, as in Egypt, the necessity of it was not so imperious as it was afterwards in Italy, and latterly in Europe; the former countries abounded in quarries of marble, from which they could collect pieces of sufficient dimensions to compose lintels for all their apertures, and also for the roofs of their porticos, which were formed of marble; and they appear to have been satisfied with this application, without having had recourse to arching, which they must, had not their marble been adequate to the support of great weights laying in horizontal positions. The Romans, who were indebted to the Greeks for all that they performed on scientific principles in architecture, took the rules that were afforded in arching (although scanty) by their teachers, and if they did not much improve them, made them more common; hence we find, in most of the Roman edifices arches in all positions, in some of which there is great boldness of design, as well as intelligence displayed; but, as is usual in the infancy of an invention, they appear never to have carried them above, or varied them from, the portion of a circle, altering its versed sign only to answer the numerous purposes of strength and ornament in building.—The ancient Roman architects do not appear to have been guided, in these their principles of arch building, by certain and geometrical principles, experience and imitation served them principally as guides. The circle with them answered every purpose; and experience having shewn its utility, no one seems to have pressed from the ranks to exhibit his enterprise by a deviation; this was left for the work of the moderns, and, like the late developements in chemistry, to which it nearly approaches in both genius and importance, may, in its results, eventually connect the most distant by the easiest possible means, as well as promote the convenience of the present and admiration of succeeding ages.

The masonry of an arch herein to be treated of, is so intimately connected with the theory, that it appears almost impossible to ex-

plain the one without giving some information respecting the other. In theory, an arch may be explained as follows, *viz.* to consist of a series of stones, called voissoirs, in the shape of truncated wedges which resist each other, through their inclined sides, by means of that weight whereby they would otherwise fall, and are suspended in the air without any support from below, where a concavity is formed. The voissoirs are subject to forces which arise from their own weight, from external pressure, from friction, and the cohesion of matter; all these forces compose a system which ought to be in equilibrio; and moreover, that state ought to have a consistence firm and durable. It was not till near the end of the seventeenth century when the Newtonian mathematics opened the road to true mechanical science, that the mathematicians directed any part of their attention to the theory of arches. Dr. Hook gave the first hint of a fixed principle, when he affirmed, that the figure into which a chain or rope, perfectly flexible, will arrange itself, when suspended from two hooks, becomes, when inverted, the proper form for an arch constituted of stones of uniform weight and size. The reason on which he grounded his assertion, is, simply, that the forces with which the parts of a standing arch press mutually on each other, in the latter case, are precisely equal and opposite to those with which they pull each other in the case of suspension. This principle, true as far it goes, gave rise to most of the specious theories of the mathematicians; for they did not consider that though an arch of equal voissoirs might be thus balanced, it would require much other matter to be placed over it, to fill up the space between the extrados and a road way, if used for the purpose of a bridge, and that this superincumbent mass must necessarily destroy the equilibrium previously existing in the unloaded arch. There is a certain thickness in the crown which will put the catenarian in equilibrio, even with a horizontal roadway; but this thickness is so great that the pressure at the vertex is equal to the horizontal thrust: the only situation, therefore, in which the catenarian would be proper, is in an arcade, carrying a height of dead wall above it. During these discussions on the celebrated catenaria, a new system of arching developed itself. It was deduced from the consideration of the arch-stones being frustrums, or parts of wedges; hence the mathematical properties of the wedge were introduced into the science, and employed to establish the theory of what were called balanced arches; this practice was taught in France by La Hire, Parent, Varignon, Be-

lidor, Riou, &c., and some bridges were formed on its principles, *viz.* Pont La Concorde, at Paris, and also one arch at Nieully. It required that the arch-stones should be as long as economy would admit, and, if possible, to fill up all the space between the intrados and extrados of the bridge; and further, they are all to be locked together by bars and wedges of iron, which will prevent the possibility of their sliding, on the arch quitting the centering; a circumstance not before accomplished in arching.

The theorist not yet having brought the practical architect to adopt his sentiments, raised another system, which is said to secure a perfectly equilibrated structure, by making an equality at every point of the curve. The deduction from this theory consists in making the height of the wall incumbent on any point of the intrados, directly as the cube of the secant of the curve's inclination to the horizon at that point, or inversely as the radius of curvature there. It must be added that this theory expects the joints of the voissoirs to be perfectly smooth, and not to be connected by any cement, and therefore to sustain each other merely by the equilibrium of their vertical pressure: and the theorist says, " an arch which thus sustains itself, must be stronger than another which would not, because when in imagination we suppose both to acquire connexion by cement, the first preserves the influence of this connexion unimpaired; whereas in the other, part of the cohesion is wasted in counteracting the tendency of some parts to break off from the rest by want of equilibrium. From these systems have been made tables for forming arches to equilibrate, by which the nature of each voissoir may be found to any degree of curvation, and Dr. Hutton has simplified it for practical men." The practical mason, however neat in the execution of his work, finds it extremely difficult to get the joints of the arch-stones so smooth as is required by these systems; and, even if he succeeds in doing so, circumstances may take place in the construction of the work to render it useless; for instance, the abutments may sink a little, and one may retire more than another, hence will arise an alteration in the arch, and, consequently, in the shape of the joints; but there are other circumstances to be anticipated, known to the practical architect (if even a sinking of the abutments should not take place), which is an alteration in the centre on which the masonry is raised. It is ascertained, that however firmly it may be constructed and supported, its curvature will vary as it receives the weight of the stone arch. It not being possible that the

centre could be loaded all at once, produces this variation; but even if the centre should be so constructed as to remain firm and unalterable, a sinking will ensue on its removal; this, as the practice is, is done gradually, and all the arch-stones in some measure follow it; the middle ones squeezing the lateral ones aside, which compresses all between them; hence the latter arch-stones alter their shape, a sinking of the crown ensues, consequently a general change of form of not only the joints, but of the arch also. Some architects, to secure as little friction in the joints as possible, have covered their surfaces with sheet-lead, and this practice was followed in the bridge of Blackfriars, at Norwich, by Mr. Soane. It cannot be too strongly recommended to the mason concerned in arch building, to make all the joints meet as correctly as possible, using the least possible quantity of cement between them: the practice of wedging in the voissoirs at the crown of the arch, commonly practised, should be done with caution, or, instead of preventing a sinking, it may endanger the whole arch. Peronet, who was architect to so many bridges in France, and whose experience and sagacity in this branch of practice had developed more than a whole magazine of theorists could do, rejected it. His rejection of it was not however to the principle, but to the uncertainty in the persons employed to perform it; he conceived that the stones might be so fractured in forcing them in, that no two flat surfaces would present themselves in that part of the arch.—Nieully, one of the finest bridges he built, and which the writer of this article has repeatedly examined, is of a very superior construction; the road occasions very little elevation, no more than sufficient to keep it dry. The arches and piers are quite unique in their shape, of considerable span, and so apparently flat and thin in the crown, as at first sight to create a doubt if they be of stone. It is a principle in the French bridges that the passengers may see their roadway from one end to the other. It would not be endured by them to be ascending mountains over the inland waters; and if their bridges are not so strong as ours, they exhibit more of elegance, convenience, and beauty.

The figures of arches are as various in their shape as the most fastidious ideas of convenience can require; they were, in the bridges of the Romans, semi-circles; by the moderns, of every form and curvature fancy can suggest, or geometry delineate; but the practical mason should endeavour in constructing arches, if he expects the praise of intelligent men, to protect them by some reference to known prin-

ciples. Every arch of curvature (and it cannot be an arch without it, although it may be a lintel) should be described by its praxis in known geometry, and if it require one, two, or more centres to develope its form, the workman should not forget that these points once ascertained are his guides to find the shape of the voissoirs or arch-stones. The joints of an arch are all traced from the centres of their curvature, so that as a general axiom it may be assumed, for instance, speaking of a semi-circle, that its centre supplies the principle of giving form to the voissoirs; if a segment, the centre of the circle of which it is the segment, be its versed sign what it may. If an ellipisis, which is neither more nor less than three segments, the arch-joints must be drawn from the centres of each correspondent circle, and so on to the parabola, hyperbola, &c.: if these principles were attended to by the practical mason, the failure of so many arches in the smaller works would be prevented, and the arch itself appear more neat; inasmuch as *fixed* principles would be opposed to that which is most commonly done by chance, as may be seen by any attentive observer, on looking at the arches in some of our buildings,

Stone-cutting, to which we have already had occasion to call the reader's attention, may be equally well done by various methods; the most certain consists in forming as many plane surfaces to the stone as may be necessary, in such a manner that these surfaces may include the intended form, with the least waste of stone, or in the most convenient way for applying the moulds. Upon the plane surfaces thus prepared, the proper moulds are to be applied, and the stone worked to them. It will generally happen that the bed of the stone will be one of the first plane surfaces, and the arrangement should always be made, so that there may be as little re-working as possible.

It may here be remarked, that the young mason should be extremely careful to avoid making the beds of stones concave or hollow. For, if this be done, in any case where the stones have to bear much pressure, they will flush, or break off in flakes at the joints, and entirely disfigure the work. It is better that they should be slightly convex. In the construction of piers and columns, where perfection of form is at least as much regarded as strength, this maxim should be carefully attended to. Nothing can be more offensive to the eye than a flushed joint, since it not only deforms, but also gives the idea of want of strength.

The bond of walls requires to be most carefully attended to in the

construction of piers, angles, and, in general, every part exposed to great strain.

On this subject it also may be remarked, that crossing the joints properly is a more effectual means of bonding a wall than that of employing very long stones, unless they be very strong ones. For if a stone exceed about three times its thickness in length, it cannot be so equally bedded but that it is liable to break from unequal pressure; and the fracture commonly takes place opposite to a joint, and therefore destroys the bond of the wall. This defective mode of construction we have often had occasion to notice.

In works of hewn stone destined to support great pressure,or to bear the action of a heavy sea, it is necessary that the stones should be of great bulk, and connected in the firmest manner. Sometimes this is effected by forming the stones so as to lock them together. The Eddystone and Bell Rock Light Houses are bound together at the base on this principle. Where less strength is required, iron cramps are used, and sometimes pieces of hard stone are dove-tailed into the adjoining blocks. We think cramps of cast-iron might be employed with much advantage in nearly all these cases.

The proper quantity of mortar to be employed in stone work is another point to which it will be useful to direct the mason's attention. A stone cannot be very firmly bedded upon a very thin layer of mortar; and if the stone be of an absorbent nature, the mortar will dry too rapidly to acquire any tolerable degree of hardness, however well it may have been prepared. On the other hand, if the bed of mortar be thicker than is necessary to bed the stone firmly, the work will be a long time in settling, and will never be perfectly stable.

When the internal part of a wall is built with fragments of stone, they should be closely packed together, so as to require as little mortar as possible. Walls are often bulged by the hydrostatic pressure of mortar, when it is too plentifully thrown into the interior, to save the labour of filling the spaces with stones.

The walls of houses are frequently built with hewn stone on the outside, and rubble stone on the inside. The settlement of these two kinds of stone work during the setting of the mortar are so different, that the walls often separate; or where this separation is prevented by bond stones, the walls bulge outwards, and bear unequally on their base. These evils are best prevented by using as little mortar as possible in joints of the interior parts of the wall, and not raising the wall to a great height at one time.

In London, the value of stone occasions it to be cut into scantlings by a saw, and the operation is done by the labourer; in different parts of the country where stone abounds, it is divided into smaller scantlings by means of wedges. Hard stone and marble are reduced to a surface by a mallet and chisel.

A valuable substitute for Portland Stone chimney-pieces, has been rewarded by the Society for the Encouragement of Arts. The process may be thus described:—Take two bushels of sharp drift sand, and one bushel of sifted slaked quicklime, mix them up together with as little water as possible, and beat them well up together for half an hour, every morning for three or four successive days, but never wet them again after their first mixture.

To two gallons of water, contained in a proper vessel, add one pint of single size, made warm; a quarter of a pound of allum, in powder, is then to be dissolved in warm water, and mixed with the above liquor.

Take about a shovel full of the first composition, make a hole in the middle of it, and put therein three quarters of a pint of the mixture of allum and size, to which add three or four pounds of coarse plaster of paris; the whole is to be well beaten and mixed together rather stiff; put this mixture into the wooden moulds of the intended chimney-piece, the sides, ends, and tops of which moulds are made of moveable pieces, previously oiled with the following mixture.

Take one pint of the droppings of sweet oil, which costs about one shilling the pint, and add thereto one pint of clear lime water, made from pouring boiling water on lumps of chalk lime in a close vessel till fully saturated, when the lime water becomes clear, it is proper to be added to the oil as above-mentioned, and on their being stirred together they will form a thick oily mixture, or emulsion, proper to apply upon the moulds.

In forming the side or jamb of a chimney-piece, the mould is to be first half filled with the sand-lime and plaster composition, then two wires wrapped round with a thin layer of hemp, and which wires are nearly the length of the piece to be moulded, are to be placed in parallel lines, lengthways, in the mixture or composition in the mould, and afterwards the mould is filled up with more of the composition, and if there is any superfluous quantity, it is to be struck off with a piece of flat board.

The lid or top part of the mould is to be then placed upon it, and

the whole subjected to a strong pressure from powerful levers or a screw press. The composition to remain under this pressure for twenty or thirty minutes; the precise time necessary may be known, from examining a small specimen of the composition reserved purposely to determine the time it requires to harden and set firm.

The sides of the mould are to be held together by iron clamps and wedges.

The wires above-mentioned answer a double purpose, by giving strength to the jambs, and retaining the whole mass together in case it should at any time be cracked by accident.

The chimney-pieces may be made either plain or fluted, according to the mould, and when moulded, they are finished off by rubbing them over with allum water, and smoothing them with a trowel, and a little wet plaster of paris.

A common plain chimney-piece of this composition, is sold at only seven shillings, and a reeded one at twenty-eight shillings, completely fitted up.

The principal instruments used in London for hewing stones are the mallet and edge tools. The form of mason's tools, which are used by the percussive blows of the mallet, is that of a wedge; the cutting edge is the vertical angle. The material out of which such tools are made is iron, except the end which enters the stone, which is of steel. The end of the tool which is struck by the mallet is a small portion of a spheric surface, and projects on all sides beyond the adjoining part or hand hold, which increases in magnitude towards the middle of the tool, and tapers forward, in the form of a wedge or pyramid, to the entering or cutting edge. The other tools used by the mason are, a level, a plumb rule, a square, a bevel, and rules both straight and circular, of various descriptions, for trying the surfaces in the progressive state of the work.

The tools used in London, in succession, to work the face of a stone, are, the point, the inch tool, the boaster, then the broad tool. The operation of working with the point is called *pointing*, and that with the boaster is called *boasting*. The operation of the point leaves the surface in narrow furrows, with rough ridges between them. The inch tool is used in cutting away the ridges, and the boaster in making the surface of the work nearly smooth. The point is in breadth, at the entering part, from one-eighth to three-eighths of an inch, the boaster two inches wide, and the broad tool three inches and a half at the cutting edge. In the use of the tool, the cutting edge is always

perpendicular to the same side of the stone. There are two kinds of operations performed by it: suppose the impression made by the whole breadth of the tool, at the cutting edge, to be called a cavity. In one operation, the successive cavities follow one another in the same straight line, until the breadth or length of the stone is exhausted; then successive equidistant parallel lines are repeated in the same manner, until the whole surface of the stone has been gone over by the tool. This manner of hewing is called *stroking*, which is a kind of fluted surface. In the other operation, every successive cavity is repeated in new equidistant lines throughout the length or breadth of the stone, then a new series of cavities is again repeated throughout the length or breadth of the stone, and thus until the whole breadth or length of the stone is exhausted. This mode is called *tooling*.

Tools for working cylindrical and conical parts of mouldings are of all sizes, from one-eighth part of an inch upwards; but those for working convex mouldings are generally half an inch broad, unless in confined spaces, where such breadth cannot be admitted.

A stone is taken, for the greater part, out of winding with points, and entirely with the inch tool.

In London, the facings of buildings made with squared stone, are either stroked, tooled, or rubbed.

In the country, where the saving of stone by the use of the saw is not a compensation for the loss of time taken up in sawing, the operation is entirely performed by the mallet and chisel.

When stones are very unshapely previous to the operation of hewing, a stone axe, jedding axe, scabbling hammer, or cavil, is used, in order to bring the stone nearly to a shape; one end of the jedding axe is flat, and is used for knocking off the very protuberant angular parts when less than right angles, the other end is pointed for reducing the different surfaces nearly to the intended form.

In some parts of the country, different fancies of hewn surfaces are indulged, as herring-bone work; this is forming the surfaces of the stones by zig-zag lines parallel to each other.

In Scotland, besides what has already been noticed in hewn work, are other kinds denominated droved, broached, and striped. Droving is the same as that called random tooling in England, or boasting in London; and the chisel for broaching is called a punch, and is the same as that called a point in England. Broached work is first droved and then broached, as the work cannot be done regularly at once with the punch. Striped work must also be first droved and then striped.

Hence, of these three kinds of surfaces, the droved is the cheapest. Though broaching is sometimes performed without droving, it is never so regular; and besides, the surface is generally full of inequalities. It must be observed, however, that workmen in general do not take the same pains to drove the face of a stone which is to be afterwards broached, as in that of which the droving is to remain the final finish; these should be noticed by the superintendant. Droving, broaching, and striping, are the terms used in Edinburgh and Glasgow, and in the south of Scotland. In Aberdeen, where the stone is very hard, being a kind of granite, the same operations cannot be employed. Instead of them they use a scabbling hammer, by which they pick the stone until the surface has nearly acquired its intended form. This manner of dressing the surface for the stone facing of a building is called *nidged work*, and the operation *nidging*. The term rubbed work is applied where the surface is smoothed by means of sand or grit stone.

Various curved rules, or templets and gauges, are also employed in hewn work. The tools used in setting or building are, a line and line pins, the level, the plumb rule, and rules of various descriptions, as also templets for circular work.

Marbles are polished by first being rubbed with grit-stone, then with pumice-stone, and lastly with emery or calcined tin.

In the admeasuring of mason's work the measurer is provided with two rods, commonly of five feet in length each, divided into five equal parts or feet, and each foot again subdivided into halves and quarter feet: sometimes the feet are also drawn in inches, but this latter method is by no means universal. When the stone to be measured approximates to fractions, the common rule is applied to ascertain them. All the stone is first measured, beginning at that which is fixed nearest to the top of the building, and then taking the labour to it; and every piece of stone which exceeds in its thickness two inches is valued by the cubic foot, and all other stones under that thickness are deemed to be slabs, and are valued at per foot superficial; these latter generally embrace the paving-stones of all descriptions, as well as chimney-pieces, copings, &c. There are also some portions of the labour as well as the stone which are valued by the foot measure running; of this class are the groovings in lusticated work, flutings in the shafts of columns and pilasters, joints in gallery floors, (called joggled joints,) rebates in stairs, with the throatings to cills and copings, &c. &c. In the latter description may be included the various sorts of copings employed on the tops of walls and parapets, narrow

slips to chimney pieces, &c. &c. The dimensions are all accurately put down in a book, which for convenience is ruled into three divisions on its left hand side, the middle division being about one third of the width of those on its sides; this middle column is that in which the inches and parts are expressed, and in the left hand column the feet, together with the number of times the dimension is to be repeated or added, and the last for placing the quantities when cubed and squared; for in taking the dimensions it often happens that there may be several pieces of stone of the same size, and this the measurer marks in his book, as well as at the same time writing down the nature of the stone, and also the species of labour about it. His dimension book stands thus:

3*f*6 : 0 3 : 0 : 9	3 : 4½	Portland Landing.
3*f*7 : 6 3 : 9	84 : 4	Plain Work Do.
3*f*7 : 6	22 : 6	Groove Do.

By thus arranging the dimension book, every particle of stone and labour on it is ascertained with the greatest accuracy and dispatch; they are all afterwards to be abstracted, which consists in ruling out a loose sheet of paper into as many columns or divisions as are required for all the several species of work which has been measured, and writing over the head of each of the columns the particular kind to be inserted in it; for instance, beginning with cube of Portland, all of it which has been measured is brought into the column under that head, plain-work under its head, also sunk-work, moulded work, and the several running measures all stand respectively: and when so separated, they are to be cast up at the bottom of each several column, where is to be seen the whole of the several quantities, after which they are made out into bills, beginning with the cubes first, then the superfices, and lastly the running measures. The works which are valued singly or by their number, are similarly classed and placed last of all at the bottom of the account. For thus measuring, cubing, and squaring the quantities, and valuing and finishing the account, surveyors charge two and a half per cent on the gross amount.

Stone cills to windows, &c. are, in general, about four inches and three quarters thick, and eight inches broad, and are weathered at the top, which reduces the front edge to about four inches, and the horizontal surface at the top to about one inch and a half on the in-

side; so that the part taken away is six inches and a half broad, and three-quarters of an inch deep. Cills, when placed in the wall, generally project about two inches and a half. The horizontal part left on the inside of the cill is denominated *plain work;* and the sloping part *sunk work;* and in the dimension book are entered thus:—

1½
4
2½
—
8 inches the breadth of the plain work in the cill according to the above dimensions,—then

	4 8	2 8	Plain work.
	4 6½	2 2	Sunk work.
2	8 4	6	Plain to ends.
	4 0		of throating.

No account is taken of the sawing.

Cornices are measured by girthing round the moulded parts, that is, the whole of the vertical and under parts, called moulded work:— for example, suppose a cornice project one foot, girth two feet, and is forty feet in length, then the dimensions will be entered as under:—

40 2	80	Moulded work.
40 1	40	Sunk work at top.

All the vertical joints must be added to the above.

Cylindrical work is measured in the girth; and the surface is calculated to be equivalent to plain work twice taken.

For example, suppose it be required to measure the plain work, or a cylinder, ten feet long, and five feet in circumference, the dimensions would then be entered

10 0 5 0	500 Sup^{l}. plain work, double measure.	

Paving-slabs and chimney-pieces are found by superficial measure, as also are stones under two inches thick.

The manner in which the dimensions of a house are taken, vary according to the place and the nature of the agreement.

In Scotland, and most parts of England, if the builder engages only for workmanship, the dimensions are taken round the outside of the house for the length, and the height is taken for the width, and the two multiplied together gives the superficial contents. This, however, applies only when the wall is of the same thickness all the way up; and when not, as many separate heights are taken as there are thicknesses. This mode of measuring gives something more than the truth, by the addition of the four quoins, which are pillars of two feet square; but this is not more than considered sufficient to compensate the workmen for the extra labour in plumbing the quoins.

If there be a plinth, string, course-cornice, or blocking course, the height is taken from the bottom of the plinth to the top of the blocking course, including the thickness of the same; that is, the measurer takes a line or tape and begins, we will suppose, at the plinth, then stretching the line to the top, bends it into the offset, or weathering, and, keeping the corner tight at the internal angle, stretches the line vertically upon the face of the wall, from the internal angle to the internal angle of the string; then girths round the string to the internal angle at the top of the string, and keeping the line tight at the upper internal angle, stretches it to meet the cornice; he then bends it round all the mouldings to the internal angle of the blocking course, from which he stretches the string up to the blocking course, to the farther extremity of the breadth of the top of the same; so that the extent of the line is the same as the vertical section stretched out: this dimension is accounted the height of the building.

With respect to the length, when there are any pilasters, breaks, or recesses, the girth of the whole is taken at the length. This method is, perhaps, the most absurd of any admitted in the art of measuring; since this addition in height and length, is not sufficient to compensate for the value of the workmanship on the ornamental parts.

The value of a rood of workmanship must be first obtained by estimation, that is, by finding the cost of each kind of work, such as plinth, strings, cornices, and architraves, &c. and adding to them the plain ashlar work,and the value of the materials, the amount of which, divided by the number of roods contained in the whole, give the mean price of a single rood. When the apertures or openings in a building are small, it is not customary to make deductions either for the materials or workmanship which are there deficient, as the trouble of plumbing and returning the quoins is considered equivalent to the deficiency of materials occasioned by such aperture.

Elsam's Gentleman's and Builder's Assistant, gives the following information on the practice of measuring rough stone work.

To find the number of perches contained in a piece of rough stone work.

If the wall be of the standard thickness, that is, twelve inches high, eighteen inches thick, and twenty-one feet long, divide the area by twenty-one, and the quotient, if any, will be the answer in perches, and the remainder, if any, is feet. If the wall be more or less than eighteen inches thick, multiply the area of the wall by the number of inches in thickness, which product, divided by eighteen, and that quotient by twenty one, will give the perches contained.

Example. A piece of stone-work is forty feet long, twenty feet high, and twenty-four inches thick, how many perches are contained in it?

```
         40 length.
         20 height.
        ----
        800
         24
        ----
       3200
      1600
     ------ 21)      P.  F.  In.
 18) 19200  (1066  (50  16   8
     18      105
     ---     ---
      120     16
      108    ---
      ---
       120
       108
       ---
        12 equal to 8 inches.
```

The method last described, of finding the value of mason's work, is usually adopted, the perch being the standard of the country; but the most expeditious way of ascertaining the value, is to cube the contents of the wall, and to charge the work at per foot. To ascertain the value of common stone-work, a calculation should be made of the prime cost of all the component parts, consisting of the stones in the quarry, the expense of quarrying, land-carriage to the place where it is to be used, with the extra trouble and consequent expense in carrying the stone one, two, three, or more stories higher. Also the price of the lime when delivered, together with the extra expense of wages to workmen, if in the country; all these circumstances must be taken into consideration in finding the value of a perch of common stone-work, the expense of which will be found to vary according to local circumstances, in degrees scarcely credible; on which account a definite price cannot, with propriety, be fixed.

In the choice of different stones for public or private edifices, the contiguity of certain stones, and the ease with which they could be obtained and worked, would be first attended to, particularly in the early periods of architectural science; but there cannot be a doubt that durability and beauty were soon regarded as essential qualities of building stone, and those stones which possessed these properties in a remarkable degree, were sought for with great assiduity, and conveyed to distant countries at a great expense.

Such was the care of the ancients to provide durable materials for their public edifices, that, had it not been for the desolating hands of modern barbarians, and the inevitable destruction attendant on warfare, many of the temples and other public works of the Greeks and Romans would have remained perfect to the present day, uninjured by the action of the elements during a period of more than 2000 years.

On the contrary, in modern Europe, and particularly in Great Britain, there is scarcely a public building of recent date which will be in existence a thousand years hence. Many of the most splendid works of modern architecture are hastening to decay, in what may be justly called the very infancy of their existence, if compared with the date of public buildings that remain in Italy, in Greece, in Egypt, and the East. This is remarkably the case of the three bridges of London, Westminster, and Blackfriars, the foundations of which began speedily and visibly to perish in the very life-time of their founders. The same observation is applicable to Somerset-house, and many other public buildings in London; the fine chiselling of the *alto relievo* figures having already disappeared by the action of the elements mouldering away the stone. The most careless observer may notice, that this effect is more rapidly taking place in some stones than in others in each of these buildings, though they are all of Portland stone, a calcareous stone, called roe-stone by mineralogists, and obtained from the isle of Portland.

We have reason to know, that very little attention was paid to the selection of the stones during the building of Somerset-house; and the damaged ones, or those which contained hollows lined with clay, were not rejected, but the hollows were filled up with mortar. No soft calcareous stone, such as Portland stone, can be very durable in a climate like that of England, where it must be exposed to the action of frequent rain; and for the foundation of bridges, scarcely any stone could be more unfit.

The qualities requisite for building-stone in bridges or water-works,

are hardness, tenacity, and compactness, with the property of resisting the decomposing effects of water and the atmosphere. Beside the strength necessary to support their own weight in such buildings, they may have also to resist the impetus of floating bodies, and particularly of large masses of ice. Those stones which are the hardest, are not precisely those which have the most tenacity or toughness, of which we have a familiar illustration in common lime-stone and glass; the latter, though much harder, is far more easily frangible than the former.

In public national buildings, intended to preserve the memory of the ages in which they were constructed, and to perpetuate the state of the arts at the period of their erection, beside the properties which ensure durability, we require a certain degree of beauty in the stone itself.

The causes that accelerate the decay and destruction of stone in buildings, are nearly the same as those which occasion the destruction or wear of rocks on the surface of the globe: they may be classed into two kinds, those of decomposition, and those of disintegration. By the former, a chemical change is effected in the stone itself; by the latter, a mechanical division and separation of its parts. The decomposition takes place, when the stone contains parts that are more or less soluble in water, or which enter into combination with oxygen or acids. To have a distinct idea of the decomposition of stones, we must first consider the elementary parts of which they are composed: these are either silex, alumine, or lime, to which we may add magnesia, which though of more rare occurrence, enters largely into the composition of serpentine and some lime-stones. Iron, in different states of oxydation, and in different proportions, enters also into the composition of almost all stones, and is frequently an important agent in their decomposition. The different kinds of building-stones may, therefore, be classed as siliceous, argillaceous, calcareous, and magnesian.

Of these, the siliceous are the least liable to decomposition; silex being insoluble in water, or any of the acids, except the fluoric, which is never found in a free state. Stones composed almost entirely of silex, if compact, may be considered as the most durable; but they are frequently brittle, and extremely difficult to work. When the silex is combined with a certain portion of alumine, as in some horn-stone and jasper, it constitutes a stone which may be regarded as imperishable, when compared with the duration of states and empires. Such stones frequently contain imbedded crystals of quartz and fel-

spar, and are then denominated porphyries. Porphyry, with a compact siliceous base of hornstone or jasper, is far more durable than granite, and is peculiarly appropriate for columns or obelisks destined to transmit the events of former times to distant ages of the world. Some porphyries are also very beautiful, and take a high polish.

Granite is a compound siliceous rock, which varies much in the proportion of its constituent parts, and its degrees of induration. Compared with many rocks, granite may be considered as forming a durable building-stone; but those granites that contain much white felspar, and only a small portion of quartz, like the greater part of the granites of Cornwall and Devonshire, are liable to decomposition and disintegration much sooner than many of the Scotch granites, in which the quartz is more abundantly and equally disseminated. In the selection of granite in Cornwall and Devonshire, the preference is given to that which can be raised in the largest blocks, and worked with the greatest ease; and for common purposes, or for paving-stones, it may answer very well; but for the foundations and piers of bridges, the harder granite will be found much more durable. The present state of Cornwall proves the rapid disintegration and decay of its granite rocks. The felspar in that granite contains a large portion of potass, and to this its more rapid decomposition may be principally ascribed. The naval hospital of Plymouth (an establishment which does honour to the country) is built of Cornish or Devonshire granite, which appears to have been well selected. It has been erected about 70 years, and exhibits no symptoms of decay, except in the columns forming the colonnade in front of each building: here, on their more exposed sides, we have observed the felspar to be disintegrating, and lichens have already attached their roots to some parts of the surface.

With granite may be classed all granitic rocks containing a large portion of siliceous earth, particularly sienite. This rock was extensively quarried by the Egyptians at Sienna, in Upper Egypt, and afterwards by the Romans; and many works constructed of this stone, preserve the marks of the chisel fresh to the present day. Of the rocks here enumerated, we have abundance in various parts of the British empire; and in the construction of national works, the selection of the stone should not be left to the discretion of architects, few of whom have made mineralogy any part of their studies. Many of the sand-stones, in what are called the secondary strata, are composed of grains of silex; and where these are united by a siliceous cement, they are almost as durable as granite. In siliceous sand-

stones, the coarseness or fineness of the grains is of far less importance than the substance by which they are united. Those which are united by ferruginous clay are very liable to perish by exposure to the atmosphere. Some siliceous sand-stones appear to be of alluvial formation, and have their parts so loosely cemented, that they are quite unfit for architecture: such is the sand-stone rock on which the town and castle of Nottingham are built. In the series of strata which alternate with coal, there are considerable beds of siliceous sand-stone, which vary much in their quality; some containing a large portion of clay and iron, others being almost purely siliceous. Of the latter kind are some of the lowest beds in Yorkshire and Derbyshire, which have been denominated mill-stone grit, being formerly used for coarse mill-stones. Kirkstall Abbey, near Leeds, is built of this stone: it is now a ruin, but the stones which remain are perfect, and preserve their angular sharpness as fresh as if they had been recently worked, though six hundred years have elapsed since the erection of this building. There is a quarry of similar stone in the neighbourhood extensively worked at present. It may be proper to observe, that in all quarries of sand-stone, the strata vary considerably in their power of resisting the effects of the atmosphere. Some strata are marked with stripes and veins, and these are frequently found to be more perishable than the general mass of the stone. We have known such stones preferred for the fronts of buildings, on account of their supposed beauty; but, in the course of a very few years, the coloured parts began rapidly to decay, by the action of water on the iron, which these parts contain more abundantly than the rest of the stone. From what has been stated, it may be seen that stones, which are purely siliceous, are of all others the least liable to decomposition; but where there is an admixture of *silex* with different substances, great skill is required in their selection for durable architecture. Some directions for the choice of such stones will be subsequently given.

Argillaceous stones, or those which contain in their composition a considerable portion of clay, are generally found to contain also a large portion of iron. This metal appears to have a greater affinity for argil or clay than for any other earth, and is frequently combined with argillaceous stones in the proportion of one-fourth of the whole mass. The iron is frequently in the state of black oxyd, and in this state rapidly combines with a larger portion of oxygen, when exposed to the atmosphere, and thus occasions the surface of the stone to swell and shiver away. We have seen stones of this kind in their

native beds, some hundred feet under the surface, so extremely hard that they resisted the point of the pick, and could only be removed by blasting; yet when the same stone was exposed for some months to the air, it became soft, and shivered into small pieces. It rarely happens that builders or engineers have sufficient mineralogical science, to enable them to anticipate the changes which will be effected by air and moisture on the materials they select. The loss which this ignorance has occasioned in the construction of many public works is well known. A remarkable instance of this kind took place a few years since in Paris. A gentleman was walking with an eminent mineralogist in one of the newly erected public edifices. They were particularly struck with the appearance of some large columns that supported the roof. On a closer inspection, the mineralogist predicted that they would perish in less than three years. About ten months afterwards, the gentleman had occassion to pass through the same building, and observed workmen were then removing the columns, and replacing them with a different stone; the decay having been so rapid, as to render their removal necessary.

In forming the tunnel of the Huddersfield canal, in Yorkshire, through Pule Moss, a lofty mountain three miles in breadth, the workmen, in one part, had to cut through a dark argillaceous stone, so extremely hard, that they were obliged to remove it by blasting. On account of its hardness and compactness, it was deemed unnecessary to wall the passage on the part which was cut through this bed; but in a few months after the access of air, it shivered and fell in, and the removal and repair occasioned much delay and expense. Many basaltic rocks, which are almost as hard as flint in their native beds, on exposure to air or moisture, are soon covered with a brown incrustation, which penetrates deeper and deeper into the stone, till the whole is reduced to a soft pulverulent mass: this is occasioned by the rapid absorption of oxygen, the iron in the basalt being in a low state of oxygen.

On this account, basaltic stones are ill suited for durable architecture, though there are some stones of this class which appear more perfectly vitrified, and resist the action of the atmosphere for ages. This is also the case with lavas which are nearly allied to basalt: some lavas rapidly decompose and form a fertile soil, others remain unchanged for centuries. In all stones called argillaceous, the quantity of alumine, or pure clay, is, in fact, generally less than that of the other earths. Alumine or clay, when pure, is soft and unctuous, and absorbs more than $2\frac{1}{2}$ times its own weight of water. It com-

municates, in a greater or less degree, its own properties to stones, where it is combined in the proportion of from 20 to 30 *per cent.* The properties of clay are lost by vitrification, or by exposure to a strong heat, as we may observe in the process of brick-making. In the West Riding of Yorkshire, it is frequently the practice to mend the roads with argillaceous sand-stone; but it is soon reduced to mud: to prevent which, it is piled in heaps, with alternate layers of coal, and burned before it is laid upon the roads: this makes it more durable, but the heat is seldom sufficiently powerful to vitrify the stone, and the roads frequently want repair. The remains of vitrified forts in some parts of Scotland prove that the North Britons were acquainted with the durability imparted to argillaceous stones by exposure to great heat. In situations at a great distance from durable building-stone, it would be advantageous to have the bricks employed in the construction of bridges exposed to a greater degree of heat, and vitrified on the surface. This may be more easily effected by a mixture of calcareous earth with the clay.

Calcareous stones include all the different kinds of lime-stone, from the most crystalline marble to chalk and calcareous sand-stone. Of marbles, there is an almost infinite variety; indeed every variety of lime-stone that admits of a good polish is denominated marble. The lime-stones or marbles that occur in primitive mountains, among blocks of granite, gneiss, and mica-slate, are generally the most durable, as they are highly crystalline; and many of them contain a considerable portion of siliceous earth, which communicates a greater degree of hardness to such marble. Though calcareous earth is in a certain degree soluble in water and carbonic acid, yet in its most indurated state, as in primitive marbles, the action of the atmosphere produces little change in the course of centuries; but when exposed to the constant action of water, the decomposition is more rapid. Those marbles which are the most uniform in their texture, which possess the greatest degree of specific gravity and hardness, and which will receive the highest polish, are those which will prove the most durable. There is another test applicable to marbles, and all stones purely calcareous, which affords no bad proof of their durability.

Let a given weight of different marbles be cut into cubes, or any other regular figure, and immersed in dilute muriatic acid of the same degree of strength: that marble which dissolves most slowly will be the least liable to decay.

Some lime-stones consist of calcareous earth, combined with a

considerable portion of magnesia: the primitive lime-stones which contain this earth have a milky whiteness. All lime-stones of this kind dissolve very slowly in acids; and such of them as possess the other properties of hardness and an uniform texture, may be considered as the most durable of all marbles. The importance of an uniform texture is evinced in the different durability of the Parian and the Pentelic marbles. They were both extensively employed by the sculptors and architects of ancient Greece. In the age of Pericles, the preference was given to the latter. The Parthenon was built entirely of marble from mount Pentelicus (Pentelic marble), near Athens. Many of the Athenian statues, and the temples of Ceres or Eleusis, were of this marble. The preference arose from its superior whiteness, and probably from its vicinity to Athens. It is remarked by Dr. Clarke, that while the works executed in Parian marble remain perfect, those of Pentelic marble have been decomposed, and sometimes exhibit a surface as earthy and rude as common lime-stone. This is principally owing to veins of extraneous substances which intersect the Pentelic quarries, and which appear more or less in all the works executed in this kind of stone. The Parian marble has somewhat of a waxy appearance when polished; it hardens by exposure to the air; it receives with accuracy the most delicate touches of the chisel, which it retains for ages, with the mild lustre of the original polish. The Medicean Venus, the Diana Venatrix, the colossal Minerva, (called Pallas of Veletri), and the Juno, called Capitolina, are of Parian marble. The Parian tables at Oxford are also of this stone. Of the marbles of South Britain, those of Devonshire are by far the most beautiful: for the Anglesea marble, as it is called, is principally pure serpentine, though it is classed by professor Jameson, in the late edition of his Mineralogy, with granular lime-stone. The Devonshire marbles have scarcely been noticed by mineralogists, but many of them possess a degree of beauty scarcely inferior to any of the foreign marbles, particularly those of Babicomb. They are veined and spotted with a variety of colours, from a bright red to a beautiful dove-colour, and are susceptible of a very high polish. The altar, and the interior of lord Clifford's elegant chapel at Ugbrook, near Chudleigh, are executed in this marble, which may vie with the most costly marbles of Greece or Italy. The great national work called the Break-Water at Plymouth, is formed of blocks of Devonshire marble: it is an artificial mole of vast extent, and now forms a bay, where our largest fleets ride in safety. The marble is procured at Cat Down quarries, close to the water's edge, from

whence it is conveyed in boats about two miles, and thrown into the sea. The blocks are raised of vast dimensions by blasting, and from their hardness and size may resist the decomposing effects of sea water for ages, particularly if the western side should get a covering of sand. The contiguity of the stone necessarily determined the choice where some million tons were wanted to complete the work, but there cannot be a doubt that the granite of Cornwall would have made a more durable barrier.

Among the secondary lime-stones, there are some which contain a considerable quantity of magnesia, particularly in the counties of Nottingham, York, and Durham. These lime-stones have generally a yellowish colour: they dissolve slowly in acids, and form a very durable stone for architecture. York Minster is said to be built of this stone.

The roe-stone, particularly that of Portland and Bath, is very extensively employed in architecture: it can be worked with great ease, and has a light and beautiful appearance; but it is porous, and possesses no great durability, and should not be employed where there is much carved or ornamental work, for the fine chiselling is soon effaced by the action of the atmosphere. On account of the ease and cheapness with which it can be carved, it is much used by our English architects, who appear to have little regard for futurity.

The chapel of Henry VII. affords a lamentable proof of the inattention of the architect to the choice of the stone. All the beautiful ornamental work of the exterior had mouldered away in the short comparative period of three hundred years: it has recently been cased with a new front of Bath stone, in which the carving has been correctly copied; but, from the nature of the stone, we may predict that its duration will not be longer than that of the original. Probably the architect was limited by contract, which precluded the use of a more durable, but more costly stone. Portland, as well as Bath stone, varies much in its quality: and we think greater attention was paid to its selection in the construction of St. Paul's church, than in many of the modern edifices built of this stone. Though we have observed many stones in the upper part of the building mouldering away, yet, on the whole, it is less injured by the weather than Somerset-house. In buildings constructed of this stone, we may frequently observe some of the stones nearly black, and others presenting a white clean surface. The black stones are those which are more compact and durable, and preserve their coating of smoke; the white stones are decomposing, and presenting a fresh surface, as if they had been recently scraped. This effect is strikingly exhibited in the

columns of Somerset-house, in which black and white stones may be seen alternating in the same column.

Some of the lower beds of chalk are occasionally used for building-stone, though, from its loose texture, it cannot possess great durability. We have seen the cloisters of Westminster Abbey, repaired with a stone of this kind, so soft as to yield to the nail; and on inquiring of the workmen why they made use of such a material? the reply was, "the cheapness of the cutting."

Alabaster or gypsum is sometimes employed for ornamental architecture. The name alabaster is also given to stalactitical lime-stone. This variety of lime-stone possesses nearly all the properties of granular lime-stone. The gypsum alabaster is a sulphate of lime, and possesses a considerable degree of solubility in water. Dr. Watson, in his Chemical Essays, states, that he suspended two ounces of this stone in a pail of water forty-eight hours, changing the water several times, and found at the end of that time it had lost one-thirtieth part of its weight. From the solubility of the gypsum, it is obviously improper for any purpose where it is to be exposed to the action of rain or water.

Of the magnesian stones, there is only one applicable to purposes of architecture; this is serpentine, which has been fully described under that article.

The disintegrating causes to which building-stones are exposed are moisture, variation of temperature, and vegetation: the action of these is distinct from that of decomposition. The earths which are not soluble in water are capable of being mechanically suspended in it, when minutely divided. A drop of water, constantly running along the hardest stone, marks its path by cutting a furrow in the surface, according to the well-known adage. This cause is, however, slow, compared with others which are constantly operating Water insinuates itself into the minute pores and crevices of stones, and being expanded by variation of temperature, and particularly by frost, breaks asunder the hardest stone, or shivers off a portion of the surface. Those stones which have a laminated structure are most liable to be injured by the effects of frost, from the facility with which water insinuates itself between the laminæ.

Lichens and mosses fix their roots on the surface of stones, particularly on those argillaceous stones which yield an earthy smell when breathed upon. By insinuating their roots, they accelerate the decay of such stones, and prepare a vegetable mould for plants of a larger growth.

In calcareous and other sand-stones, where the cementing material is of a soft kind, it is washed out by rain, and the stone falls in pieces, or moulders away. In general, those stones which are the most hard, compact, and uniform, in their texture, and which can be brought to the smoothest surface, are those least liable to disintegration. In order to form a judgment of the durability of any building-stone, which has not had the test of experience, it is desirable to examine it in its native bed, particularly those parts of the bed which have been long exposed to the air. This may not unfrequently be done in some part of the country where the stone is quarried; for as each stratum rises in a certain direction, it will come to the surface somewhere, if not covered by soil. The stone, in such situations, offers certain indications of the effect which atmospheric agency produces upon it. Where this examination cannot be made, all stones that are not calcareous may be in some degree proved, by observing what effect is produced upon them by immerging them in water for a given time, by exposing them to a red heat, and to frost, or by covering them with dilute nitric acid for several days. Those stones which absorb the smallest quantity of water, and which are least changed by the action of heat, frost, or acids, may be fairly considered as most capable of resisting the decomposing or disintegrating effects of moisture and change of temperature. We have before suggested a test in the choice of calcareous stones. It has recently been the practice to rub the calcareous sand-stones with oil; and this must to a certain degree resist the absorption of water, and contribute to the durability of the stone.

Foreigners generally class building-stones into two kinds, hard and soft. In the latter they comprise all stones that can be cut with the saw in any direction, and with some degree of ease: the hard stones are all those which cannot be worked by the same process. In England, the name free-stone is given to all the softer stones, which can be cut easily with the saw into large blocks suited for building-stone: it includes a variety of sand-stones very different in their nature.

It may be enough to state in conclusion, that experience has taught our architects, that all stratified stones last much longer, when laid in the same direction which they had in their native quarries; a circumstance which ought always to be attended to by the mason. As stratified stones generally split with the greatest ease in the direction parallel with the surface of the strata, it is obvious that they will bear less pressure in this direction than in a line perpendicular to their natural position.

THE

CARPENTER'S AND JOINER'S

COMPLETE GUIDE.

CARPENTRY AND JOINERY.

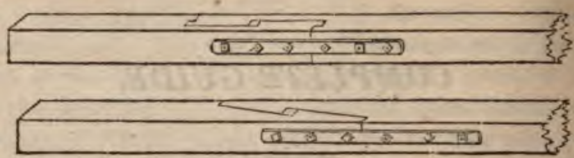
THE art of carpentry, generally speaking, includes every method of working or employing timber, or its substitutes, in the construction of buildings: but, as it is evident that coarse rough work requires very different management from the delicate finish of interior arrangement, it is divided into two classes:—*Carpentry*, properly so called, to which belongs flooring, roofing, and the working of all large pieces of wood; and *Joinery*, which includes all ornamental works in wood (except what is obviously within the province of the cabinet maker), besides doors, window sashes, and other objects intended for close inspection.

The latter subject will be considered hereafter. Under the former, we shall treat, first, of the methods of joining timber; secondly, of the construction of floors, roofs, &c.; and thirdly, of the strength and stress of timber.

Timbers are joined either sideways, endways, perpendicularly, or obliquely. When the fibres of one piece are parallel with the fibres of the other, they are said to be joined *sideways*. When the joint is perpendicular to the fibres of both pieces, it is called by workmen a butting or heading joint, and they are said to be connected *endways*. When the fibres and joint of one piece are at right angles to those of the other, the joint is said to be *transverse* or *perpendicular*; and when the fibres of the two pieces run in an oblique direction to each other, it is called an *oblique* joint.

Timbers are usually connected by means of a mortise and tenon the former of which is an indentation in the wood, and the latter a cor responding projection; sometimes by wooden pins, &c.; and wher great strength is required, as in roofs, they are further secured b fastenings of iron.

Of the methods of joining timbers laterally, scarfing is one, whic is sometimes parallel, and sometimes oblique. Of the following figure the first represents the former, the second the latter; but the variet in the particular forms of the pieces is endless.



Of these, the former figure is also *tabulated:* that is, to rend the joints as close as possible, and the juncture more independent the bolts (which are seen at the side), the pieces are indented to gether.

Another method of joining timbers laterally is by keys and dove tails, which may be employed in connecting parallel pieces where the do not touch each other.

Butting joints for many purposes are preferable to scarfings, part cularly in small work. They are fixed together with bolts, having screwed nut at each end; the head of one of these nuts must b quite round, and the other square; the round one must be cut in i circumference full of notches. After having let in the bolt perpend cularly to the joint in both pieces, the nuts are sunk from one sid across the grain till the ends of the bolt can pass the interior screw made for the purpose of receiving the exterior one; the square nut i first put in, and one end of the bolt is firmly driven into the bor made to receive it, and screwed to the nut. The other notched nut i then put in, and the bolt in its place; the one piece may be turne round upon the other till the joint is close; but in order to secure th joint from turning round, two dowels may be inserted on each side o the bolt. Drive the one piece as close to the other as the nut wi permit; then, by means of a narrow screw-driver and mallet, the nu may be turned round till the joint is quite close.

One mode of fixing a piece *perpendicularly* to another is by *fox-tail wedging*, which is thus performed:—In the piece forming th base, a mortise, decreasing towards the top, is to be cut nearly th

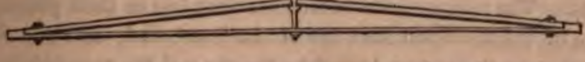
whole depth of the wood; a parallel tenon is then to be made in the upright piece, corresponding with the upper part of the mortise; to the end of this two wedges are to be fixed, which, when the piece is driven into the mortise, will, by the resistance offered by the bottom, split the end of the tenon, and cause it to expand in such a manner as to fill the mortise. In order to ensure a still closer fit, two other smaller wedges may be employed, whose ends do not project so far as the larger ones.

Oblique Joining is chiefly used for the rafters, &c. in roofs, and is generally performed by cutting a notch in the parallel piece and letting the oblique one into it.

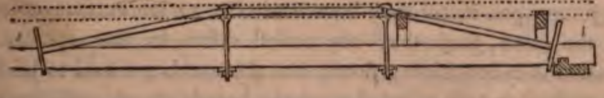
We have now, under our second proposed head, to treat of *flooring*, &c.

In the construction of houses, as commonly practised in London, a piece of timber is placed about midway between the front and back walls to which it is parallel; this is called the girder. Smaller pieces (called *binding joists)* proceed from this to the walls, where they are received on other pieces let into the wall, called *wall plates.* Under and over the binding joists are fixed smaller pieces, the former of which are called the *ceiling joists,* and the latter *bridging joists.* It is scarcely necessary to add, that on the bridging joists are laid planks, and to the ceiling joists are affixed laths, for the plaster of the ceiling.

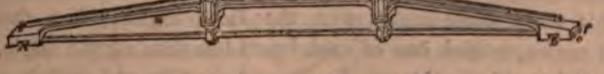
When the girders are very long, or the weight the floors are destined to support is very considerable, they are *trussed;* that is, for a simple beam is substituted a frame so constructed that the pressure is thrown more upon the walls, and the possibility of the beam being broken is prevented.



This diagram represents a truss of iron bolted at the ends.



This truss is intended for a very great length of girder



This truss is constructed wholly of iron, and is calculated to support considerable weight.

Flooring.

For boarded floors, it is observable, that the carpenters never floor their rooms with boards till the carcase is set up, and also inclosed with walls, lest the weather should injure the flooring. Yet they generally rough plane their boards for flooring before they begin any thing else about the building, that they may set them to dry and season, which is done in the most careful manner. This operation should be performed for at least one year, so that the natural sap may be thoroughly expelled. The best wood for flooring is the fine yellow deal, well seasoned, which, when well laid, will keep its colour for a long while; whereas the white sort becomes black by often washing, and looks very bad. The battens used for flooring are of three kinds; the best is that free of knots, strakes, sap, and cross-grained fibres, well-matched. The second best is that in which only small but sound knots are permitted, and free of strakes and sap. The third and common kind is that which remains after taking away the best and second best.

With respect to the joints of flooring boards, they are either quite square, or plowed, or tongued, or rebated, or dowelled. They are always necessarily nailed upon both edges when square jointed, without dowells. When they are dowelled, they may be nailed on one or both edges, though one edge is necessary; and in the best dowelled work there are no brads or nails seen whatever, the outer edge being fastened by driving the nail obliquely through the wood, without piercing the upper surface, so that the floor, when planed off, appears without blemish.

In laying boarded floors, the boards are sometimes laid one after the other: or otherwise one is first laid down, then the fourth, leaving an interval somewhat less than the breadth of the second and third together. The intermediate boards are next laid in their places, with an edge of the one upon the edge of the first board, and one edge of the third upon the inner edge of the fourth, and the two middle edges together, which will form a ridge; to level which, two or more workmen jump upon it, till they have made the under surface coincident with the joists, then they are nailed down in their places. The operation is called folding floors, and the boards are said to be folded. This method is only adopted when the boards are not sufficiently seasoned, or suspected to be so. In order to make close work, it is obvious that the two edges forming the joint of the second and third boards must make angles with the faces together less than two right angles, or each one of each board less than a right angle. The seventh board is fixed as the fourth, and the fifth and sixth inserted as the second and third, and so on till completed. In this kind of flooring the headings are generally square or splayed.

When floors are dowelled, the regulating line for the centre of the dowells should be drawn from the lower side, which, as has been observed, ought to be straightened on purpose. The distances to which the dowells are set are from six to eight inches, generally one over each joist, and one over each inter-joist.

When it is necessary to have a heading joint in the length of the floor, it should always be upon a joist: one heading joint should never meet another. In dowelling floors the heading points are always plowed and tongued.

In common floors the boards are adzed on the lower side in order to bring them to a thickness between rebated edges. In doing this, great care should be taken so as not to make them too thin, which is frequently the case; they must then be raised with chips, which is a very unstable resistance to a pressure on the floor. The manner of measuring floors is by the squares, or ten feet on each side, so that taking the length and breadth, and multiplying them together, and cutting off two decimals, the contents of a floor in squares will be given. Thus 18 by 16 gives 288 of two squares and 88 decimal parts.

The next subject for consideration is one of the most important branches of the art of carpentry; *viz. Roofs.*

The most simple form of a roof is, when one side of the building being higher than the other, pieces of wood are laid across in the position of an inclined plane, which will necessarily throw off the rain. This is called a shed roof, or lean-to, but is impracticable in buildings (except as wings to larger ones), above the rank of a cow-shed or a pig-stye. Rectangular buildings, therefore, are usually covered by a roof in the form of a prism, the vertical section of which is an isosceles triangle. The height of this, or, as it is technically called, the *pitch* of the roof, has varied, in different ages, in a very great degree. Our ancestors made them, to suit the exigencies of the climate, very high; there are some instances of roofs whose angles contain more than sixty degrees. This has gradually sunk to about thirty, the usual height in the present day. This extraordinary diminution is probably the result of the combined causes of a decreased regard to durability and disregard of expense, and an increased attachment to the Greek and Roman manner of building (in the prototypes of which, this pitch was that naturally suggested by the climate in which they were built). The advantages of high pitched roofs are, that they more readily throw off the rain and snow, and are, therefore, not so

liable to be damaged by the weather.* The wind will not find ac cess between the slates or interstices of the lead, and, therefore, wi not be so likely to strip them, or blow the wet into the timbers an rot them; its pressure will be more perpendicular, and it will bear lighter covering; there will, therefore, be less strain upon the wal But it is considerably more expensive, as it requires larger timbers make it equally strong. The peculiar advantages of those of a lc pitch will be already perceived. They are less expensive; they a indispensable in the Greek and Roman styles of architecture, whic having been naturalized among us in our more important edifices, re gulates the taste of the rest, though without architectural pretensions

In most of the countries of the East, the roofs are made flat. The not being subject to such vicissitudes of weather as in our climat obviates the principal disadvantage of this form: and the convenienc of it for walking on, in a sultry climate, constitutes a great advantage In this country, however, flat roofs are not found desirable, and are very seldom employed.

When the sides of the roof of a building, regular or irregular in its plan, are all inclined, the roof is said to be *hipped*.

When the inclined sides of a roof are not carried up till they meet but are finished in a plane parallel to the horizon, the roof is said t be *truncated*.

When the roof of a circular building is constructed in the figure c a cone, it is called a *revolved* roof.

When the roof of a circular or regular polygonal building is s constructed that the vertical section is a regular curve, and all the ho rizontal sections are concentric with its plan, it is called a *dome*.

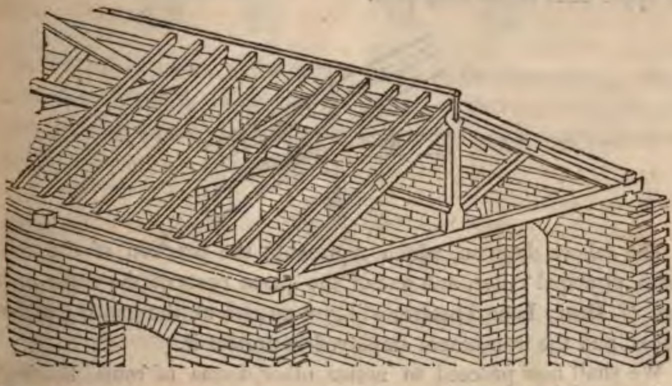
Having now mentioned every variety of roof, we shall consider, i the first place, that form most generally employed, and consequentl of the greatest importance, namely, the prismatic.

The simplest manner of constructing this form of roof, is evidentl by inclining pieces of wood to each other, while their opposite extre mities rest upon either wall. But it will require no great profundit of theoretical investigation, or extent of practical experience, to per ceive, that by this means the whole weight of the timber and its co vering will be exerted at the greatest possible advantage to thrust ou the walls. Something, therefore, becomes necessary to counteract th

* Thus rendering them very useful for the climate of England. See o preceding article on *Architecture*.

dangerous action: and, for this purpose, a beam is introduced which acts as a string to keep the walls together. When, however, the span is considerable, this beam is apt to sink in the middle from its great length. To obviate this, a post is suspended from the vertex to which the beam is attached. From the point of intersection two pieces proceed obliquely to the centres of the two pieces which constitute the exterior of the frame. Thus every part contributes to the support of the rest, and the frame so constructed is the simplest form of a *truss*.

The following diagram represents this truss, with the other parts of a roof, as commonly executed in London.



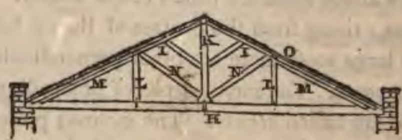
The large horizontal pieces of timber which extend from wall to wall are called *tie beams*, and rest at each end upon the *wall plates.* Any other beams above these are called *collar beams*. The large perpendicular pieces, rising from the centres of the tie beams, are called *king posts*. In large roofs there are other perpendicular pieces which are called *queen posts*. The inclined pieces proceeding from the base of the king post are called *struts*. The inclined pieces supported by the king post, struts, and the extremities of the tie beam, are called *principal rafters*. The piece which is parallel to the wall plates and is supported by the ends of the tie beams, is called the *pole plate.* The piece which runs along the top and is supported by the king post is called the *ridge piece*. The piece which runs parallel to this and the pole plate, and midway between them, is called the *purlin*. The

small pieces which run parallel to the principal rafters, and are supported by the pole plate and purlin, resting in the ridge piece, at the extremity, are called *common rafters* or *spars.*

It has been already observed that the office of the king post is to support the tie beam; and it may not be improper here to mention the manner of connecting the parts together. The suspension of the king post from the principal rafters is evidently a matter of great importance: this is effected by forming the head of the king post wider than the rest of it; this is bevelled at right angles with the inclination of the rafter, which is firmly mortised into it; the projecting parts are called *joggles.* Sometimes, to render it yet more secure, an iron strap is added, which is bolted into each piece. The king post is sometimes connected with the beam by being mortised into it, and secured with pins; but the best method is to suspend it by an iron strap resembling a stirrup, which passes round the beam and is fastened at its upper ends to the king post.

The above diagram, which represents the junction of the collar beam, principal rafter, and one of the queen posts of the truss of the roof of Drury Lane Theatre, will give an idea of the jointing of those pieces, and the iron braces employed to protect it.

We shall now proceed to notice other forms of roofs, bearing in mind that the great aim of all these contrivances is to render the pressure on the walls as directly perpendicular as possible.

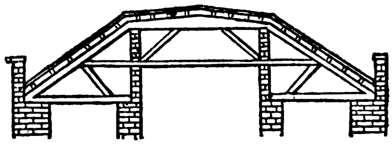


The above diagram represents a roof, designed by Mr. Isaac Ware, on the principles of a bridge in Palladio's third book in his Treatise on Architecture, Chap. VII. It is sixty feet span, and is only such a modification of the common truss, as is necessary to adapt it to so large a span: there is, however, a peculiarity in the construction of

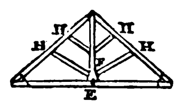
the head of the king post; it is not joggled, but has tenons projecting from it which fit into corresponding mortises in the ends of the principal rafters. The following are the scantlings:—

		Inch.	Inch.
H.	Beam	12 by	8
I. I.	Principal rafters	10	8
K.	King post	10	8
L.L.	Queen posts	10	8
M.M.	The under rafters to the principals	8	8
N.N.	Struts	8	8
O.O.	Common rafters	6	3½

The beam may be scarfed in three pieces

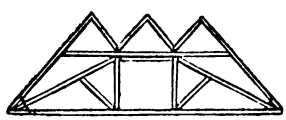


The principal peculiarity of this truss is in the crown piece. The oof of the chapel of Greenwich Hospital, constructed by Mr. S. Wyatt, appears to have been suggested by this, which was published in 1756.

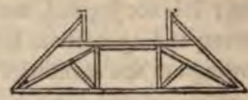


This truss is designed for a span of forty-four feet, and was in the time of the inventor the common pitch of roofs. The scantlings are as follow:—

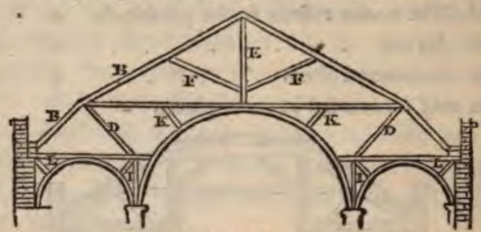
		Inch.	Inch.
E.	The tie beam	10 by	8
F.	King post	10	8
G.G.	Principal rafters	10	8
H.H.	Purlins	8	6



The span of this truss is fifty-four feet. It appears to be well adapted for a place where room is wanted in the roof, and strength, without great expense, is desirable.

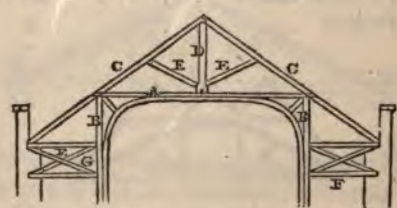


The same form is here represented divested of the three small roofs, to allow of a platform at the top. It loses, however, at the same time, much of its strength, and has, besides, all the disadvantages of a flat roof, it being impossible completely to drain it.



The truss here represented is considered by Mr. Ware to be the best form for the roof of a church of this description. The following are the scantlings :—

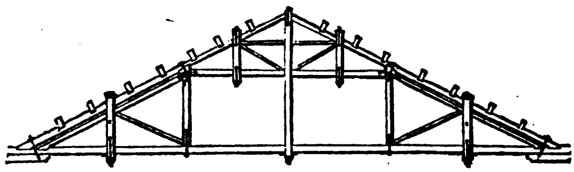
		Inch.		Inch.
A.	The upper beam	12	by	8
B.B.	Principal rafters	10		8
C.C.	Lower beams	10		8
D.D.	Braces from lower to upper beam . .	10		8
E.	King post	10		8
F.	Struts	8		8
G.	Middle rib for the ceiling, to be in four parts	8		6
H.	Side ribs, ditto	8		6
I.I.	Puncheons on top of columns . . .	10		8
K.K.	Braces to middle rib	6		6
L.L.	Braces to side ribs	6		6



This truss bears great resemblance to that of the roof of St. James's Church, Piccadilly, esteemed a master-piece of Sir Christopher Wren. The following are its scantlings :—

Roof of Covent Garden Theatre.

		Inch.		Inch.
A.	The beam	12	by	9
B.B.	Puncheons on the top columns .	12		9
C.C.	Principal rafters	12		9
D.	King post	12		9
E.E.	Struts	6		6
F.F.	Under short beams	12		9
G.G.	Braces	8		8



Truss of the roof of Covent Garden Theatre, by Mr. Smirke.

The following general table of Scantlings, from Price's "British Carpenter," may not be unacceptable to the reader.

A TABLE FOR THE SCANTLINGS OF TIMBER.

A Proportion for Timbers for small Buildings.

Bearing Posts of Fir.

Height.	Scantling.
if 8 Feet	4 in. square.
10	5
12	6

Bearing Posts of Oak.

Height.	Scantling.
if 10 feet	6 inch. square.
12	8
14	10

Girders of Fir.

Bearing.	Scantling.	
if 16 feet	8 inch. by	11
20	10	12½
24	12	14

Girders of Oak.

Bearing.	Scantling.	
if 16 feet	10 inch. by	13
20	12	14
24	14	15

Joists of Fir.

Bearing.	Scantling.	
if 6 feet	5 inch. by	2½
9	6½	2½
12	8	2½

Joists of Oak.

Bearing.	Scantling.	
if 6 feet	5 inch. by	3
9	7½	3
12	10	3

Bridgings of Fir.

Bearing.	Scantling.	
if 6 feet	4 inch. by	2½
8	5	2¾
10	6	3

Bridgings of Oak.

Bearing.	Scantling.	
if 6 feet	4 inch. by	3
8	5½	3
10	7	3

Small Rafters of Fir

Bearing.	Scantling.	
if 8 feet	3½ inch. by	2½
10	4½	2
12	5½	2½

Small Rafters of Oak.

Bearing.	Scantling.	
if 8 feet	4½ inch. by	3
10	5½	3
12	6½	3

Beams of Fir, or Ties.

Length.	Scantling.	
if 30 feet	6 inch. by	7
45	9	8½
60	12	11

Beams of Oak, or Ties.

Length.	Scantling.	
if 30 feet	7 inch. by	8
45	10	11½
60	13	15

Principal Rafters of Fir. Scantling.

Length.	Top.		Bottom.	
if 24 ft.	5 in. &	6	6 in. &	7
36	6½	8	8	10
48	[illegible]	10	10	12

Principal Rafters of Oak. Scantling.

Length.	Top		Bottom.	
if 24 ft.	7 in. &	8	8 in. &	9
36	8	9	9	10½
48	9	10	10	12

A Proportion for Timbers for large Buildings.

Bearing Posts of Fir.

Height.	Scantling.
if 8 feet	5 in. square.
12	8
16	10

Bearing Posts of Oak.

Height.	Scantling.
if 8 feet	8 in. square.
12	12
16	16

Girders of Fir.

Bearing.	Scantling.	
if 16 feet	9½ inch. by	13
20	12	14
24	13½	15

Girders of Oak.

Bearing.	Scantling.	
if 16 feet	12 inch. by	14
20	15	15
24	18	16

Joists of Fir.

Bearing.	Scantling.	
if 6 feet	5 inch. by	3
9	7½	3
12	10	3

Joists of Oak.

Bearing.	Scantling.	
if 6 feet	6 inch. by	3
9	9	3
12	12	3

Bridgings of Fir.

Bearing.	Scantling.	
if 6 feet	4 inch. by	3
8	5½	3
10	7	3

Bridgings of Oak.

Bearing.	Scantling.	
if 6 feet	5 inch. by	3½
8	6½	3½
10	8	3½

Small Rafters of Fir.

Bearing.	Scantling.	
if 8 feet	4½ inch. by	3
10	5½	3
12	6½	3

Small Rafters of Oak.

Bearing.	Scantling.	
if 8 feet	5½ inch. by	3
10	7	3
12	9	3

Beams of Fir, or Ties.

Length.	Scantling.	
if 30 feet	7 inch. by	8
45	10	11½
60	13	15

Beams of Oak, or Ties.

Length.	Scantling.	
if 30 feet	8 inch. by	9
45	11	12½
60	14	16

Principal Rafters of Fir. Scantling.

Length.	Top.		Bottom.	
if 24 ft.	7 in. &	8	8 in. &	9
36	8	9	9	10½
48	9	10	10	12

Principal Rafters of Oak. Scantling.

Length.	Top.		Bottom.	
if 24 ft.	8 in. &	9	9 in. &	10
36	9	10	10	12
48	10	12	12	[illegible]

We have next to consider the construction of *hipped roofs.* To find the length of the hip, (which is the line produced by the meeting of the two inclined planes) in a regular square, it is only necessary to take one half of the diagonal, and on one extremity to raise a perpendicular equal to the proposed height of the roof. A line drawn from the summit of this to the other extremity will be the required length. The same principle applies to all rectangular figures, and regular polygons. When the plan of the building is an irregular polygon or a trapezium, it is usual to cut off the top of the roof in a plane parallel to the horizon, to avoid the disagreeable effect of an oblique ridge.

The construction of *domes* is generally allowed to be one of the most difficult branches of the art of carpentry. The trusses indeed are the same in principle as those in any other kind of roof, but the necessary modification of the parts, and the connection of them at the top, requires considerable skill. The principles which must be observed in these constructions are, to be cautious that the pieces stand equally close from the springing to the apex; to cut the pieces short alternately; to make the horizontal ties of sufficient strength to render it impossible for any parts to fly out at the bottom, or for the dome itself to exercise an improper strain upon the wall, of which, however, there is seldom much danger, as the domes usually constructed are rarely of segmental forms; the most common, being hemispherical and hemispheroidical.

Perhaps the most extraordinary dome ever constructed is that of the Halle du Bled, at Paris, designed and executed by le Sieur Molineaux. Although two hundred feet in diameter, its thickness does not exceed one foot; notwithstanding which, it has stood in perfect safety ever since its erection, which was early in the last century. Molineaux first proposed his plan to the magistrates of Paris, who, struck with its magnificence, were yet diffident of its practicability, and referred it to the Royal Academy. A committee of this body having thoroughly investigated the design, gave it their entire approbation, and expressed their sense of the merits of the construction. It was accordingly quickly carried into execution.

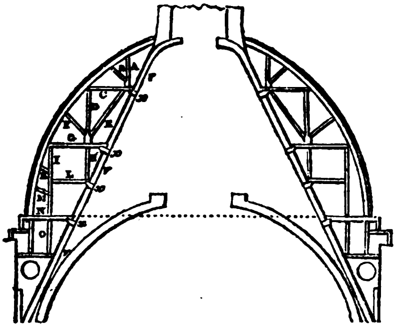
The principles of its construction are extremely simple. The ribs which compose it, are formed of planks nine feet long, thirteen inches wide, and three inches thick. These are bolted together in such a manner that one covers the joint of that in contact with it. When in their progress towards the vertex, these become one-third nearer to each other than at their springing, every third rib was discontinued, and the interstices glazed. The same operation at the due distance was again

performed. Above this the ribs were all connected by a circular rin of timber, leaving an open space. This was protected by a glazed ca nopy, with perforations for ventilating the building.

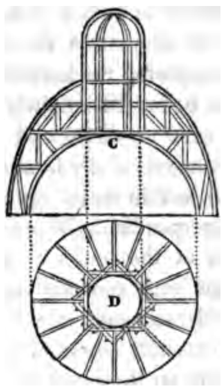
The dome of the church of St. Stephen, Walbrook, is of the sa nature with respect to its general features and purpose with that w have been describing; but that which covers the building, formerl the theatre of the College of Physicians of London, in Warwick-lane is perhaps as deserving attention as any we are acquainted with. The plan of this interesting specimen of art is, in the interior, a sex-de- cagon; and, externally, an octagon; the vertical section is an ellipse, or nearly so, about twelve feet six in height (internally.) Its internal span is forty feet, and its thickness little more than eighteen inches; and yet it sustains a lantern in the form of a cone, thirty-three feet six inches in height, of considerable solidity, and this without the aid of any extraneous braces or any visible support. When the disadvan- tageous form of this ingenious construction, the apparent slightness of its dimensions, and the great weight it has to sustain, are taken into consideration, it will be allowed that it does not deserve the neglect it has experienced. We much regret that we are not enabled to present our readers with the principles of its construction. It may not be im- proper to add, that the same building is a complete school of acousti- cal architecture; and, though it possesses little external beauty, ma justly be regarded as worthy of the talents of the architect, Sir Chris- topher Wren.

It might perhaps be deemed neglectful to pass over in silence in thi place, another work of this great man, the dome of St. Paul's cathe- dral. With respect to the construction of this stupendous erection a singular diversity of opinion has prevailed. Ordinary observers and even many who might be expected to enter more deeply into practical principles, dazzled by the enormous quantity of timber con- tained in it, having supposed this to constitute the support; while ar- chitects, and those best qualified to estimate its bearings, not only asse the cone of brick to be the *chief* support of the superstructure, bu some late writers, of skill and judgment, have declared that the im- mense trusses between this and the shell are altogether unnecessary.*

* Mr. Ware observes, "that had this great architect been a timber mer- chant, the implication would have been on his morality."



As a medium between the great waste of space in this specimen, and the apparent slightness of others, the following design is given by Price, in his " British Carpenter." It is intended for a building eighty feet in diameter in the clear.



" I suppose this a temple, standing clear from other buildings, so that one may have a beautiful view of it; as to its performance, it is sufficiently explained in the foregoing plate: the vacancy gives a great strength to it, and renders it more capable of bearing the cupola, for by framing that part of the section C. as at *a. a.* in the manner represented in D. it not only gives an opening for the light to illuminate the inside, but gives a great light to the whole.

" N.B. In all roofs of a great extent the wind is to be prepared against, as strictly as the weight of the materials which cover it, because it has so great a force in storms of wind and rain, that it acts with more violence than the materials do, they being what we may call a steady pressure.

"The plan D may be observed to consist of two square frames of timber, crossing each other, and halved together, the corners of which, and the intersections, prove a very good tie, and, at the same time, is of a resisting nature, so that it becomes the chief connection in the dome.

"I suppose this dome to consist of sixteen principal ribs, which is a mean between the foregoing one, which has but eight, and that of St. Paul's, which has thirty-two. This also may be framed with purlins, or may have ribs let into these principal ones, horizontally; so that the boards that cover it may stand upright as it were; though I don't think that a material point. If the plan were to be prepared for twelve principal ribs, then two equi-lateral triangles, crossing each other, might better suit than to half two squares together."

The equilibrium and pressure of domes is very different from that of common arching, though there are some common properties; for in their cylindrical or cylindroidal vaulting of uniform thickness, if the tangent to the arch at the bottom be perpendicular to the horizon, the vault cannot stand, nor can it be built with a concave contour in the whole or in any part, and to equilibrate the arch whether its section be circular or elliptical, supposing the intrados to be given, the two extremes of the arch must be loaded infinitely high between the extrados of the curve which runs upwards, and the tangent to the arch, which is an assymptote rising vertically from each foot or extreme of the arch. In like manner in thin dome vaulting of equal thickness, if the curved surface rise perpendicularly from the base, whatever be the contour, it will burst at the bottom. Dome vaulting, though agreeing in this particular with common vaulting, differs essentially in several others, for in order to equilibrate its figure, after the convexity has been carried to its full extent of equilibrium around, and equidistant from the summit on the exterior side, the curvature may then change into a concavity; for since the interior circumference of the courses is less than the exterior circumference, and therefore whatever be the pressure towards the axis the course cannot fall inwardly without squeezing the stones into a less compass, which is impossible; they must therefore be crushed to powder before such a vault can give way. Hence a vault may be executed with a convex surface inwardly and concave outwardly, and be sufficiently firm; but the strongest form of a circular or rotative vault to carry a load at the top, is a truncated cone; such as Sir Christopher Wren adopted in supporting the stone lantern and exterior dome of St Paul's: with regard to the strength of this vault, it is impossible to conceive any force acting on the summit that is capable of putting it out of equilibrium:

pressure is communicated in the sloping right line of the the cone, and perpendicular to the joints, the conic sides will tendency to bend to one side more than the other, (except gravity of the materials towards the axis, but this tendency eracted by the abutting vertical joints). The case is very in dome vaulting, since the contour is convex, there is a oad which, if laid on the top, must burst the dome outwardly, weight will be greater as the contour approaches nearer to ds of the arches of the two sides, or to a conic vaulting on base, carried up to the same altitude, and ending in the same course.

egard to the antiquity of domes, it does not appear from au- istory, that any of the ancient nations, prior to the time of the mperor Augustus, were acquainted with the use of the arch, equently not of the dome. It is probable that the arch was in- y the Greeks; but that species of it, called domes, seems to inated in Italy among the Romans or Hetrurians. The old- that history informs us of, is that of the Pantheon at Rome, he reign of this emperor, and is still entire. Its cavity is he- cal, and enriched with coffers, and terminates upwards in an called the eye of the dome. The exterior side rises from se- rees or steps, not vertically, but in a sloping direction, which a tangent to the several internal quoins of the steps; and ntly presents to the eye a truncated segment of a sphere much a hemisphere.

ome of the temple of Bacchus is also hemispherical inter- it without coffers. It is now covered externally with a com- , which perhaps might have been the original form, a form also to be seen in the roof which covers the dome of the Jupiter in the palace of Dioclesian at Spalatro in Dalmatia. ere of very frequent use among the Romans, as may be seen coins, and in the remains of their ancient edifices. But hough the mother of architecture, has not furnished us with xample of a dome, which may be said to be built; for that vers the monument of Lysicrates is only a single stone, and re but a lintel.

it of antiquity, the dome of Santa Sophia at Constantinople xt in order. It was built in the reign of the emperor Justi- Anthemius and Isidorus, whom the emperor had selected as eminent of the Grecian architects. As this church had been

several times burnt, it was determined that no combustible materials should be employed in its fabrication. Anthemius had boasted to Justinian that he would outdo the magnificence of the Roman Pantheon, by suspending in the air a much greater dome. For this purpose he raised four pillars on the angles of a square, distant from each other about 115 feet, and nearly of the same altitude. As this church was to be made in the form of a cross, and to be vaulted with stone, it became necessary to throw arches over the pillars, and to fill up the four angular spaces between the archivolts, gradually forming them into a complete circle at the level of the four summits of the arches. Upon this circular ring the dome, the first ever erected upon pendentives, was raised. The pressure of the eastern and western arches was resisted by walls almost solid, running longitudinally in a meridional direction, two from the north and two from the south sides of the pillars, to the distance of about ninety feet, forming transepts. It was thought that the cylindrical walls covered with half domes, which abutted on the eastern and western arches, would have made a sufficient resistance to the pressure of the arches on the north and south; but this was not the case, for the dome gave way towards the east, and after having stood a few months, it fell with the half dome on one side. Anthemius dying, Isidorus, who succeeded to the charge, strengthened the eastern piers by filling up certain voids, and then turning the dome a second time; but its pressure was still too great for the resistance of the eastern end, which was now so much fractured, that it gave way a second time before its completion. Isidorus finding still that the push was directed eastwardly, built strong pillared buttresses against the eastern wall of a square cloister, which surrounded the building, and thence buttresses spanning over the void, and then turned the dome a third time. But though every precaution was taken to diminish its gravity, both by procuring light materials (which was pumice stone) and by reducing its thickness, the arches were so much fractured, that the architect was under the necessity of filling up the great arcades on the north and south, by other smaller ones in three stories. From these circumstances we find that professional men of this age were not so well acquainted with the principles of construction in dome vaulting as those in modern times, who perhaps would have hooped or chained such a dome immediately over the arches and pendentives; and by this means it might have been secured by making its pressure incline more towards the perpendicular, as was the practice in after ages, first by Michael Angelo in the vastly more ponderous dome of

St. Peter's at Rome: and then by Sir Christopher Wren in the interior dome and cone of St. Paul's cathedral. This dome of St. Sophia, which the Turks have preserved, is nearly 113 French feet diameter.

The veneration with which the Christian world did, and still holds for this church, gave stimulus to the erection of the dome upon the church of St. Mark at Venice, about the year of Christ 973, upon a similar plan.

Shortly after the commencement of the eleventh century, the dome of the cathedral church at Pisa was built after the same model.

The vast cathedral of St. Maria dei Foire, at Florence, was begun in 1298 by Arnolfo Lusii, who died in two years after. From the decease of this great man there was no architect to be found who could engage to execute the dome with which the original architect Arnolfo had intended to finish this edifice; in consequence of which it stood for 120 years, and then a convocation of architects was assembled; many extravagant plans were proposed, but were all rejected. Filipo Bruneleschi was at length chosen as the only person who could be entrusted with the enterprize. He carried on the building, and completed the dome without difficulty, in a manner truly worthy of his great reputation. This cupola is of an octangular shape, and of great elevation, far exceeding in dimensions any of the ancient Roman domes, and only inferior to St. Peter's in point of magnitude. It is double, or formed of two vaults, with a cavity between; it was erected without centering, and is only supported by the springing wall without buttresses.

The church of St. Peter's at Rome, the largest temple ever erected, was begun by Bramante, A. D. 1513, and carried on successively by Raphael, San Gallo, and Michael Angelo. The dome of this edifice, designed by Michael Angelo, is nearly an ellipsoid on the exterior side. It rises vertically from its base, and at the height of about fifty feet branches into two thin vaults, which gradually separate as they rise. They are connected together by thin partitions dovetailed to each shell; by this means the whole is rendered extremely light and stiff.

St. Paul's cathedral, London, constructed by that great architect and mathematician Sir Cristopher Wren, was begun A. D. 1685, and completely finished by 1710. The dome, as we have already had occasion to state, rises every five feet in the altitude, has a course of long bricks inserted the whole thickness. "The concave was turned upon a centre, which was judged necessary to keep the work even and true, though a cupola might have been built without a centre; but it was

observable, that the centre was laid without any standards from below to support it; and as it was both centering and scaffolding, it remained for the use of the painter. Every story of this scaffolding being circular, and the ends of all the ledgers meeting as so many rings, and truly wrought, it supported itself." "Although the dome wants not butment, yet for greater caution it is hooped with iron in this manner; a channel is cut in the bandage of Portland stone, in which is laid a double chain of iron, strongly linked together at every ten feet, and the whole channel filled up with lead." The exterior dome is constructed of oak timber, and supported by a cone of brick work, springing from the same base with the exterior dome, and supporting on its summit, or truncated end, a beautiful stone lantern, weighing 700 tons. This dome rises higher than a semicircle; the sides of its section being struck with centres in the base line, and would meet in an angle, if continued, in the axis of the dome.

It may be proper to observe, in this place, that all the ancient Roman cupolas, on the convex side, are a much less portion of the sphere than the hemisphere; but those from the completion of the building of Santa Sophia, to the finishing of St. Paul's cathedral, are all surmounted domes, approaching in a certain degree to the proportion of spires or towers, which were so much admired in the middle ages. Since the revival of legitimate Grecian architecture by Stewart and others, the figure or contour of the Roman dome has been again revived, particularly when the other parts of the building are decorated with any of the orders; indeed exterior domes of any description are improper, when applied to the pointed style of architecture.

The present Pantheon at Paris, formerly the church of St. Genevieve, is the construction of that distinguished architect Soufflot. Its dome is very lofty, and is sustained by four pillars arched over the cross parts. The angular spaces are made good with pendentives, which terminate in a circular ring; upon this ring is erected the cylindrical wall, which supports the dome. In this respect it is similar to St. Paul's.

In the interior of the great towers, over the intersection of the cross, in our Gothic cathedrals, we find domes rising from a square base, and generally pierced by two windows on each of the four walls, which form beautiful groins with the intersection of the domic ceiling within.

Spherical domes have this property, that they may be be intersected

by cylindrical or conic vaulting in every direction, and that the intersection will always be circles, provided that the axis of the cylinder, or cone, tend to the centre of the sphere. For every section of a sphere made by a plane is a circle, and every section of a right cylinder, or cone, perpendicular to the axis, is also a circle. Let the sphere be so cut as to make a section of an equal diameter to a section of the cylinder or cone perpendicular to the axis; then the section of the cone, or cylinder, being applied to that of the sphere, so that the centres of both may coincide, the circumferences of the circles will also coincide, and therefore only make one common line of meeting in the same plane, which is perpendicular to the axis of the cylinder, or cone: for the right line drawn from the centre of the circle, which is the section of the sphere, to the centre of the sphere, is perpendicular to the plane of this section; and since the axis of the cylinder, or cone, is also perpendicular to the same plane, the axis of the cylinder, or cone, and the remaining part of the radius of the sphere, will be in the same straight line. From this it follows, when the axis of a cylindrical, or conic vaulting, is horizontal, and tends to the axis of a spheric vaulting, that their mutual intersection must be in the circumference of a circle, the plane of which will be perpendicular to the horizon. Hence the beautiful intersections of sphero-cylindric groins, which are so much admired in our principal buildings, and which never fail to strike the mind, and excite its admiration. For to people who view such forms of groins, it appears, at first sight, that the intersection will incline towards the vertical axis of the sphere at the top; but upon reflecting upon the properties of the sphere, they will soon discover that the intersection is in a plane perpendicular to the horizon.

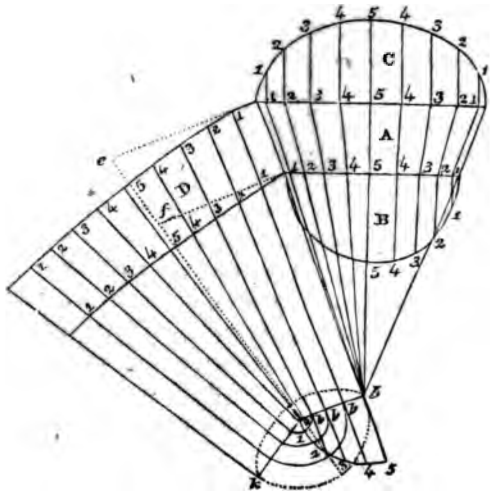
From the above principle, any building having a polygonal base, may be made to terminate in a circle, and to sustain either a cupola or cylindrical wall; for if the tops of the side walls of the polygon are brought to a level, and equal segments of circles raised on the top, meeting each other in the lines of intersection of the sides of the polygon, the segments being either semicircles, or less portions; and if the angular spaces between these circular headed walls be made good to the level of the summits of the arches, so as to coincide with the circumference of a circle, which is a great circle of the sphere, they will terminate in a circular ring at the level of the summit of the arches, and be portions of a sphere, which our workmen call spandrals, and the French pendentives. Upon the circular ring a cornice

is generally laid, and on the cornice a cylindric wall, or dome, of any description is raised.

In the practice of building, the figures of the plans of apartments on which circular domes may be created are generally squares or octagons, and the pendentives are generally equal in number to the angles of the walls; but this is not necessary, for arches may be thrown across the angles to double the number of the sides of the polygon, and to preserve the equal sides; then over the middle parts the walls may be built equal, and similar arches, touching those across the angles at the bottom, and having their summits in the same level. Instead of walls, piers may be carried to a proper height upon each angle of the polygonal plan, returning on each side of the angle; then over every two adjacent piers, on each side of the polygon, let archivolts be turned, and the spandrils filled in to the level of the summits of the arches, or archivolts, as before, and the termination will be a circle on the inside, as has been observed. The under bed of the cornice is not always laid on a level with the top of the archivolt; but the spheric surface is sometimes continued another course, or two courses, with brick or stone work; then over this a cupola or cylindrical wall may be raised. In this manner the piers of the vestibule of St. Paul's cathedral, London, have archivolts thrown over them, on each side of the octagonal plan, resting upon every two adjacent piers, forming eight arcades below, then the spandrils are filled in with spheric portions to the summits of the archivolts; upon this circular level is laid the entablature, which supports upon its cornice the whispering gallery; the cylindric wall is then carried up to the base of the dome. St. Stephen's church, Walbrook, is a beautiful example of a dome, supported upon eight arcades, the arches of which are sustained by the same number of insulated columns; the area of the vestibule is square, but the columns are so disposed in the sides of it, as to form an equilateral and equiangular octagon; the entablature, supported by the columns, is also formed upon a square plan: the archivolts between every two contiguous columns form on the plan an octagon; and the spheric spandrils, being made up to the level of the summits of the archivolts, form at last a complete circle; on this circular level is laid the cornice, which is at last surmounted with the dome and lantern.

We now proceed to another branch of our subject. A *soffit*, in theoretical carpentry, signifies the covering of any surface whatever.

Let it be required to draw a soffit in a straight wall, fluing from the jambs and level at the crown.



"A is the plan of the wall; B is a semicircle on the outside; and C is an ellipsis in the inside, traced from B, or obtained by the trammel. Draw the lines *a e*, *b f*, and *h h*, all perpendicular to *a b*, the side of the flue of A; then take half the compass of B, and lay it on *b f*; in D likewise, take half the compass of C and lay it from *a* to *e* in D, and through the points *e* and *f* draw a line to cut the line *h h h*, &c. to *h*, and continue it to *g*; put your compass in the centre of the flue at *h*, and with the other extreme point, describe the quadrant 1, 2, 3, 4, 5, which is divided into five equal parts, and draw ordinates 5 *h*, 4 *h*, 3 *h*, &c.; then take one of the divisions of the semicircle B and set the foot in *b*; make the small arch at 1, and take *h* 1 from the centre of the flue in A; then put the foot of the compass in *h*, in the soffit, and with the other foot cross the small arch at 1, and with the aforesaid division of B, set the foot of the compass in 1 in the soffit D, and describe the small arch at 2; then take *h* 2, in the centre of the flue, and set that to its correspondent *h* 2 in D, and by this means you will get one half of the soffit; put the foot of the compass in *h*, and with the other extreme *h* draw a circle, *h*, *g*, *k*; put the foot of the compass in *g*, and with the distance, *g*, *h*, that is, from *g* to *h*, the centre of the flue, describe an arc from *h* to *k*, and draw the line, *h k* where these two arcs intersect; then set the divisions of *h h h*, &c. on *h k*, and describe the other half in the same manner, and so the outline of the soffit will be completed.

Centering.

A *centre* is a temporary frame of timber used in the constructi of an arch vault, or dome of masonry. Its use is merely to susta the materials till the work is crowned by the key-stone, when, fro its nature, it needs no farther support.

In constructing a centre, regard is to be had, first, to stability, t prevent the possibility of its sinking or rising, from the pressure o its crown or haunches; and, secondly, to economy, in using no mor wood than is necessary for this end. The disastrous consequence however, of a too slight framing, will incline every prudent man i determining, as nearly as possible, the requisite degree of strengt to allow too much rather than too little material; at the same time re collecting that a small quantity of timber, skilfully employed, will b more effectual than twice the quantity put together without regard t the different degrees of pressure, and that a few additional pieces, ap plied in certain parts, may not only increase the strength of th framing, but actually weaken it, by destroying the harmony of th rest. It will therefore be our business to consider the exigencies the case, and the best methods of supplying them.

In a semi-circular or semi-elliptical arch the stones may be raised the height of thirty degress without support; thus far, therefore, th framing will experience no pressure, but there are one hundred an twenty degress left, the weight of which, in large arches, must, unde any circumstances, be very considerable. Supposing a semicircul arch to be twenty feet in diameter, one hundred and twenty degree will measure 20·9 feet; the pressure of which, supposing the stone to be eighteen inches square, and of freestone, whose specific gravit is 2,532, will be about sixty-six hundred weight and three quarters o each rib. In larger arches, the pressure is more than proportionabl increased.

Monsieur Pitot, a French writer, about a century ago, is one of th principal authors who have treated on this subject. As his princ ples are too valuable to be omitted, we shall here detail them.

It has been already mentioned, that the arch-stones need little no support till they rise to the height of thirty degrees. M. Pit then extends a stretcher from side to side, the extremities of which a supported by struts proceeding from the springing of the arch (see *fig* 1, plate X). The stretcher is supported in the centre by a king pos connected at the top with two spars proceeding from the extremities of the stretcher.

About midway between the king post and arch, on either side, the stretcher is again supported by struts proceeding from the springing

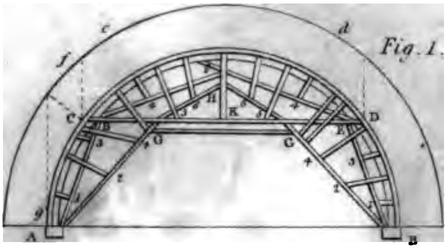


Fig. 1.

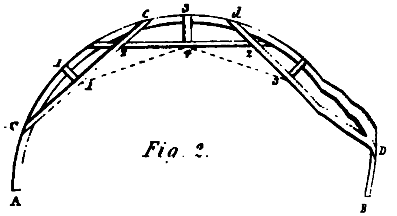


Fig. 2.

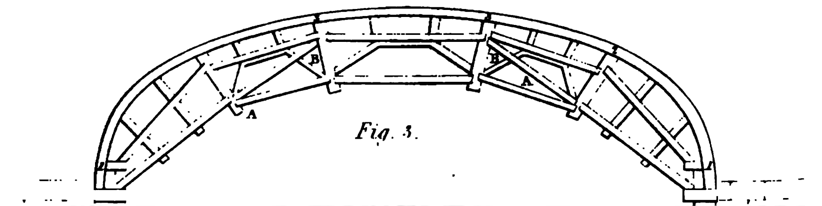


Fig. 3.

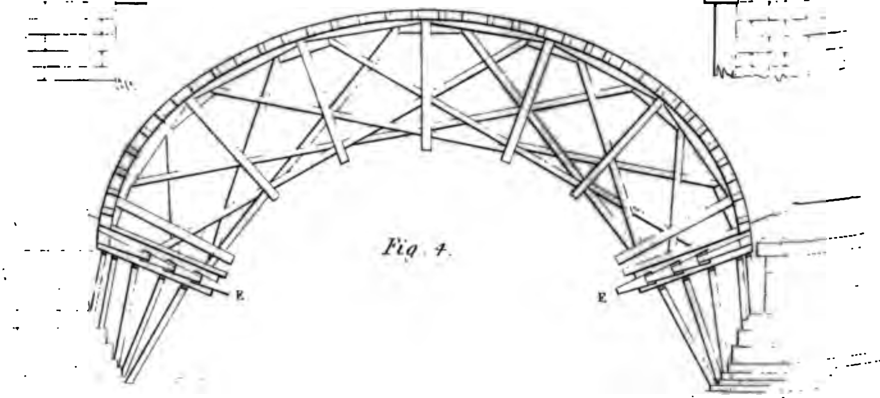


Fig. 4.

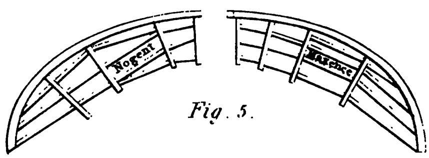


Fig. 5.

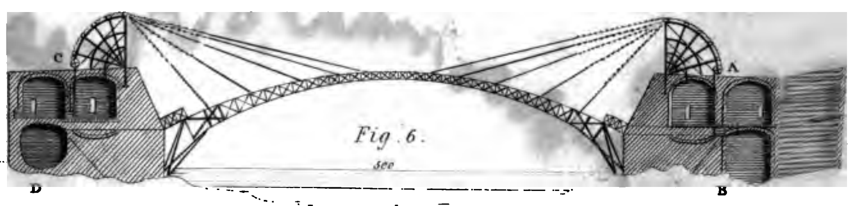


Fig. 6.

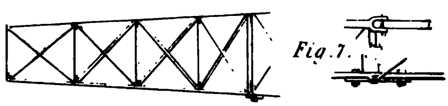


Fig. 7.

the arch, which are connected by a tie-beam under the stretcher, ich adds considerably to its strength; from these the king post de-es additional support, by two struts meeting in about its centre; ese are joined to the upper struts by transverse pieces, which pro-ed to the arch line.

Pitot intended this centre for an arch of sixty feet span; the arch-ones seven feet in length; and the weight of a cubic foot he reckons one hundred and sixty pounds. Then, as there will be no force erted on that part of the frame which is below C, the part to be pported will be fifty-three feet long, by seven broad, and three ick. The weight, therefore, will be $53 \times 3 \times 7 \times 160 = 178080$ unds.

To determine the area between the two parallels C c, fg, the line fg, rpendicular to the diameter A B, is $13\frac{1}{2}$, the base is $9\frac{1}{2}$, and C f, rpendicular to it, is seven feet, the area is $33\frac{1}{4}$ feet; C c, the base the triangle C fc, is 7·2; and fc is 7; the area is 25, and the ference is $8\frac{1}{4}$. If this difference had been the excess of the trian-e C fc, above the triangle C fg, it would have been a pressure on the frame; but as it is the reverse, the pressure is upon the utment. It is necessary to observe this distinction, in order that an necessary expense of materials and labour may not be incurred ere it is not required.

It now becomes proper to inquire, what strength of materials is re-isite to support this weight.

It has been laid down as a principle that the different pieces of tim-r composing an arch, act upon each other by their absolute strength; t that they are liable to the transverse fracture, in proportion to the gth of the piece. In a span of sixty feet, the length of the piece y be seven feet, without materially diminishing its strength, in re-cing it to the round; and by experiment we learn that the relative ength of seven feet by eight inches square is 47649lbs. We ow also from experiments, that the strength is proportioned to the pth, though care should be taken for so proportioning the breadth thickness, that the arch may be prevented from warping, the abso-e strength being nearly according to the principle of the before entioned experiment, as the squares of the depth. The absolute ength to the relative force, has been found by some to be in pro-rtion of sixty to one, but by others to be only as forty-two to one: e absolute strength of the plank (one inch thick and twelve inches de) is 189163lbs.; if the same were two inches thick, it would still

be no more than 189163. But, if it were eight inches square, then every seven feet of the arch might be broken with 189163lbs. weight. We have found, however, before, that the whole weight of the arch is only 178080 pounds, which is 11080 pounds less in weight, than that part of the frame is capable of bearing, and as seven feet is only about one seventh part of fifty-three, the frame is sufficiently strong to support the entire weight of the arch, when that weight is divided equally along its own length. This is not the case with the centre frame of an arch, as it is loaded at one place, and not at another; it is therefore apt to yield between the parts where the weight is heaviest, the form of the arch is consequently changed; for the centre frame is not limited merely to supporting the arch, but to keep and preserve it in its true form, and therefore some struts may be necessary to prevent its putting the arch out of shape. To remedy this, where the arch begins to press upon the frame at C, draw the cord line C *c*, *fig.* 6, which acts as a tie beam to the arch from C, at thirty-five degrees, to *c*, at fifty-one degrees; as beyond this, if the arch frame has altered its form, it will require it, at least, the force of the tie will have a tendency that way. All that part of the arch, where its weight begins to flatten the frame, as at 2, draw the stretcher 2 2, which likewise acts as a tie beam, while it affords support to the bridle 1, on one side, and to 3, the bridle on the other side, from D *d*; and thus the arch *c d*, is prevented from sinking by the tie beams *c d*. This will effectually prevent any yielding of the frame, notwithstanding the immense pressure of the materials composing the arch.

The relative proportions of the strength of oak and fir, have been nearly ascertained by experiments made by different philosophers, though the results of these experiments do not in all instances exactly agree. We will take that of Buffon, which is three-fifths. Now to reduce a frame of oak, to one of fir of equal strength, divide eight inches, the diameter of the oak, by three-fifths the relative strength of fir, which gives one and one-third inches. If we allow one and one half inches, then the depth of the frame will be nine and one half by two and one half inches. In this way the strength of the fir arch is rendered equal, and by the additional allowance, superior to the oak in strength, at a less expence in wood and workmanship.

M. Pitot allowed the rings of his arches to consist of pieces of oak, twelve inches broad and six thick. The stretcher CD, is twelve inches square; the straining piece CG, is likewise twelve inches square; the lower struts are eight inches by ten; the king post is

twelve inches square; the upper struts are ten by six; and the ridges are twenty by eight old French measure; which dimensions may be very easily accommodated to English measure, by observing that the old French inch is equal to 1·0657 English inches.

Pitot allows the square inch to carry 8650 pounds, that is, one half of the absolute strength, which is acertained by experiment to be about 17300 pounds, and not the square of the diameter, which would be only 16000 pounds. But on account of knots he reduces it to 7200 pounds per inch. He then computes the whole load upon the frame to be 707520 pounds, which is the weight of the whole arch stones, supposing each stone to be three feet broad, and the whole to press upon the frame, which comes very near. Pitot also supposes the weight that resists upon the center to be eleven-fourteenths of the whole weight, but assigns no reason for his conjecture. Mr. Couplet assumes that it presses by four-ninths. Our readers, however, have it in their power to examine the principles, and judge for themselves.

Figure 3, is the centre of the bridge at Orleans constructed by Hupeau, who dying before the work was completed, the execution of it was entrusted to Perronet. It is considered one of the boldest centres ever constructed in Europe. The form of the arch is elliptical, the span being 100 feet, and the height 30 feet: the arch stones are six feet in length.

Before the completion of the work by Perronet, he found the arch and frame give way, for which reason he strengthened the centre frame, by continuing the strut. By forming the base of the triangle 1, 2, 3, on each side, his frame was rendered sufficiently stiff, and the inner part below A B, became entirely superfluous. The weight that presses on the arch is great, owing to the length of the arch stone, and the flatness of the arch. That part of the arch which presses, contains about fifty-seven degrees, and measures 88·87 feet. Hence, admitting the length of the arch stone to be six feet, and its width three, we find the solid to =1596·6, and its weight, (supposing as before, the weight of a solid foot =160 pounds) to be 255456 pounds. The length of each plank of the truss being 7 feet, and its other dimensions 12 by 2, the strength is 189163 pounds. The weight for every 7 feet in length of the arch, is one-third of this, *viz.* =63054⅓ pounds, and in 88 feet, there are 756652 pounds to support 255456 pounds, which renders the arch more than three times stronger, without making any allowance for the strength of the arch, being the mean of the splitting force and transverse section; the tie beams will be of great use in stiffening the frame.

Figure 5, represents the centres of the bridges at Nogent and Mayence by the same architect (Perronet).

The centre used at Nogent, was 90 feet span, and 28 feet high; the centres used at Mayence, was of greater dimensions, and we shall therefore here consider the weight to be supported. The arch from A to C, measures 42 feet, and the arch stone 4½; now admitting the arch stones to be 3 feet broad, they would amount to 567 solid feet, which, at 160 pounds per foot, is equal to 90720 pounds. This is but little more than one half of the semicircular arch; and, although it is flatter, the weight is so much the less, that no additional strength is necessary to be given to the frame delineated in *Figure* 2, for the 60 feet span. The strength of the materials for the 90 feet arch, is likewise sufficient; that it may be rendered more stiff, on account of its greater extent, a tie beam 1, 4, 3, 4, may be added on each side of the arch, as is represented by the dotted line.

In the centering used by Perronet, it appears that notwithstanding the superabundance of wood employed, the frame was so much affected, and rose and sunk so much, that the arch deviated considerably from its intended form.

Figure 4, is the centre used in the erection of Blackfriars'-bridge, London, of which Mr. Mylne was the architect.

The span in this instance is 100 feet, and the form elliptical; the arch stones from the haunches are 7 feet; but gradually decrease in length from the haunch to the key stone.

The principles of this centre will be easily seen from a view of the figure; it consists of a series of trusses each supporting a point in the arch, the principal braces having their lower extremities abutting below, at each end of the centering, on the striking plates, and at the upper end, upon apron pieces, which are bolted to the curve that support bridgings, for binding the pieces which compose them together at their junction. This centre labours under a great disadvantage, from the frequent intersection of the principal braces with one another. The ingenious Mr. Mylne, made use of the following method of easing or disengaging the centre frame from the mason's work. Each end of the truss was mortised into an oak plank cut in the lower part as in the figure, a similar piece of oak was placed to receive the upper part of the posts. The blocks rested upon these posts, but were not mortised into them, pieces of wood being interposed instead. The upper part of these pieces was cut similar to the lower part of the other; the wedge E intended to be driven betwixt them, was notched as the figure shews, and filled up with small pieces of wood, in order

to prevent the wedge from sliding back by the weight of the arch; which not only appears from the figure as a likely circumstance, but eventually happened.

When the time for striking the centre arrived, the inserted pieces of wood were taken out, and the wedge, (prepared for driving back, by being girt with a ferule round the top,) was removed by a piece of iron driven in with the head, so broad as to cover the whole of the wood. A plank of wood after being sheathed with iron, in the same manner at the one end, was suspended, so that it could act freely in driving back the wedge to any distance, however small, and with certainty. Thus by an equal gradation, the centre was eased from the arch, which appeared to have been so equally supported throughout the whole of the operation, and the arch stones so properly laid, that it did not sink above one inch.

The method of centering proposed by Mr. Telford for the bridge over the Menai Straits, as totally differing in principle from the common form, may be not improperly mentioned in this place.

The following extracts are from his "Report to a committee of the House of Commons, on the construction of a bridge over the Menai." The centering, &c. are shown in fig. 6, and part at large in fig. 7.

"Hitherto the centering has been made by placing supports and working from below, but here I propose to change the mode, and work entirely from above; that is to say, instead of supporting, I mean to suspend the centering.

"I propose, in the first place, to build the masonry of the abutments as far back as AB, CD, and in the particular manner shewn in the section.

"Having carried up the masonry to the level of the road way, I propose, upon the top of each abutment, to construct as many frames as there are to be ribs in the centres, and of at least an equal breadth with the top of each rib. These frames to be about fifty feet high above the top of the masonry, and to be rendered perfectly firm and secure. That this can be done, is so evident, I avoid entering into details respecting the mode. These frames are for the purpose of receiving strong blocks, or rollers and chains, and to be acted upon by windlasses, or other powers.

"I next proceed to construct the centering itself: it is proposed to be made of deal baulk, and to consist of four separate ribs, each rib consisting of a continuation of timber frames, five feet in width across the top and bottom, and varying in depth from twenty-five feet near the abutment, to seven feet six inches at the middle or crown.

Next to the face of the abutment, one set of frames, about fifty feet in length, can, by means of temporary scaffolding and iron chain bars, be readily constructed and fixed upon the masonry offsets of the abutment, and to horizontal iron ties laid in the masonry for this purpose. A set of these frames, (four in number), having been fixed against the face of each abutment, they are to be secured together by cross and diagonal braces; and there being spaces of only six feet eight inches left between the ribs, (of which these frames are the commencement), they are to be covered with planking, and the whole converted into a platform fifty feet by forty. By the nature of the framing, and from its being secured by horizontal and suspending bars, I presume every person accustomed to practical operations, will admit that these platforms may be rendered perfectly firm and secure."

"The second portion of the centering frames having been previously prepared and fitted together in the carpenter's yard, are brought in separate pieces, through passages purposely left open in the masonry to the before mentioned platform. They are here put together, and each frame raised by the suspending chain bars, and other means, so that the end which is to be joined to the frame already fixed, shall rest upon a small moveable carriage. It is then to be pushed forward, perhaps upon an iron rail-road, until the strong iron forks which are fixed upon its edge shall fall upon a round iron bar, which forms the outer edge of the first, or abutment frames. When this has been done, strong iron bolts are put through eyes in the forks, and the aforesaid second portion of frame-work is suffered to descend to its intended position, by means of the suspending chain bars, until it closes with the end of the previously fixed frame like a rule-joint. Admitting the first frames were firmly fixed, and that the hinge part of the joint is sufficiently strong, and the joint itself about twenty feet deep, I conceive that even without the aid of the suspending bars that this second portion of the centering would be supported; but we will for a moment suppose that it is to be wholly suspended. It is known by experiment, that a bar of good malleable iron, one inch square, will suspend 80000 pounds, and that the powers of suspension are as the sections; consequently a bar of one inch and a half square will suspend 180000 pounds; but the whole weight of this portion of rib, including the weight of the suspending bar, is only about 30000 pounds, or one-sixth of the weight that might safely be suspended. And as I propose two suspending chain bars, to each portion of rib; if they had the whole to support, they would only be exerting about one-twelfth of their power, and considering the pro-

portion of the weight which rests upon the abutments, they are equal also to support all the iron work of the bridge, and be still within their power.

"Having thus provided for the second portions of the centering a degree of security, far beyond what can be required; similar operations are carried on from each abutment, until the parts are joined in the middle, and form a complete centering, and being then braced together, and covered with planking, when necessary, they become one general platform, or wooden bridge, on which to lay the iron work.

"It is, I presume, needless to observe, that upon such a centering or platform, the iron work, which it is understood has been previously fitted, can be put together with the utmost correctness and facility; the communications from the shores to the centering, will be through the before mentioned passages left in the masonry."

When the main ribs are fixed, covered, and connected together, the great feature of the bridge is completed, and "when advanced thus far," (proceeds Mr. Telford,) "I propose (though not to remove), yet to ease the timber centering, by having the feet of the centering ribs, (which are supported by offsets in the masonry of the front of the abutment), placed upon proper wedges; the rest of the centering to be eased at the same time, by means of the chain bars. Thus the hitherto dangerous operation of striking the centering, will be rendered gradual, and perfectly safe; insomuch that this new mode of suspending the centering, instead of supporting it from below, may, perhaps, hereafter be adopted as an improvement in constructing iron bridges, even in places not circumstanced as are the Menai Straits. Although the span of the arch is unusually great, yet, by using iron as a material, the weight upon the centre, when compared with large stone arches, is very small, taking the mere arch stones of the centre arch of Blackfriars-bridge at $156 \times 43 \times 5$, equal to 33540 cubic feet of stone, it amounts to 2236 tons; whereas the whole of the iron-work in the main ribs, cross plates, and ties, and grated covering plates, that is to say, all that is lying on the centering at the time it is to be eased, weighs only 1791 tons. It is true, that from the flatness of the iron arch, if left unguarded, a great proportion of this weight would rest upon the centering; but this is counterbalanced by the operation of the iron ties in the abutments, and wholly commanded by the suspending chain bars."

We have now to consider the subject of the strength of timber, one of the most important in the art of carpentry; since without a due

regard to it, no erections can possibly be made, but what depend solely on chance for their success. Yet, of all the branches of the science of architecture, none, perhaps, has received so little elucidation from the investigations of the learned. Nor will the cause of this seeming neglect appear problematical, when it is considered that there is none requiring such vast and expensive apparatus, more close and continued application, or more judgment and practical experience to obtain any decisive conclusions. Accordingly, in our own country, experiments have never been made on a scale sufficiently large to be of much importance as a guide in practice; and we owe to the liberality of the ancient monarchy of France nearly all the knowledge we possess on this most interesting subject. Messrs. Buffon and Du Hamel, about the middle of the last century, were directed by this government to make a variety of experiments; they were furnished with ample funds and apparatus, and all the forests of France were at their disposal for subjects. The reports of M. de Buffon may be found in the Memoirs of the French Academy for the years 1640, 1741, 1742 and 1760; and those of M. Du Hamel in his work, "Sur l'Exploitation des Arbres, and sur le Conservation et la Transportation de Bois." The essential parts of them we shall notice presently.

The investigations of an individual, however, cannot be expected to establish a science, especially one of so complicated a nature as this: and it is no imputation on the talents (confessedly great) of these gentlemen, to say that we are still in want of fixed and decisive principles for the economical and advantageous employment of timber for the purposes of carpentry.

The strength of all bodies consists in the cohesion of their particles, and as this cohesion admits of many modifications in its various appearances, of hardness, elasticity, and softness, the texture of bodies must be taken into account before we can arrive at mathematical demonstrations on the subject; and the experiments recorded, have been, for the reasons before assigned, so few, limited, and doubtful, as to produce no principles, on which to ground our future calculations.

A general idea of the force of the attraction of cohesion may be obtained from the instance of a lever, in which, by the compression of one end a strain is occasioned in a distant part. In order to understand its nature with precision it will be necessary to review such general laws as are immediately necessary as a guide in mechanical operations.

First. We have presumptive evidence to prove, that all bodies are elastic in a certain degree, that is, when their form or bulk is changed

by *certain moderate* compressions, it requires the continuance of the force producing the change, in order to continue the body in its altered state, and when the compressing force is removed, the body recovers its original form and tension.

Secondly. That whatever may be the situation of the particles composing a body, with respect to each other when in a state of quiescence, they are kept in their respective places, by the balance of opposing forces.

Thirdly. It is an established fact, that every body has some degree of compressibility, as well as of dilatability; and when the changes produced in its dimensions are so moderate, that the body completely recovers its original form on the cessation of the changing force, the extensions or compressions, bear a sensible proportion to the extending or compressing forces; and, therefore, the connecting forces are proportioned to the distance, at which the particles are diverted, or separated, from their usual state of quiescence.

Fourthly. It is universally observable, that when the dilatations have proceeded to a certain length, a less addition of force is afterwards sufficient to increase the dilatation in the same degree. For instance, when a pillar of wood is overloaded, it swells out, and small crevices appear in the direction of the fibres. After this, it will not bear half of the previous load.

Fifthly. That the forces connecting the particles composing tangible or solid bodies, are altered by a variation of distance, not only in degree, but also in kind.

Having now enumerated the principal modes, in which cohesion confers strength on solid bodies, we proceed to consider the strains to which this strength may be opposed.

These strains are four in number, viz.—

First. A piece of matter may be torn asunder :—to this strain king posts, tie beams, stretchers, &c. &c. are liable.

Second. It may be crushed :—as in the case of pillars, truss beams, &c. &c.

Third. It may be broken across, as may happen to a joist or lever of any kind, or

Fourth. It may be wrenched or twisted, as is the case with the axle of a wheel, the nail of a press, &c. &c.

With respect to the first strain, it may be observed, that it is the simplest of all strains, and that the others are but modifications of it; it being directly opposed to the force of cohesion, without being influenced, except in a slight degree, in its action, by any particular

circumstances. When a body of considerable length, such as a rope, or a rod of wood, or metal, has any force exerted on one of its ends, it will naturally be resisted by the other, from the effect or operation of cohesion. When this body is fastened at one end, we may conceive all its parts to be in a similar state of tension, since all experiments on natural bodies concur to prove, that the forces which connect their particles, in any way whatever, are equal and opposite.

If, therefore, the cohesion be equal, that is, if the body be of a homogeneous texture, the particles will be changed from their natural state, and separated to equal distances. Of course the connecting powers of cohesion thus excited and exerted, in opposition to the straining force, are also equal. This force, therefore, may be so increased as gradually to separate the particles of the body more and more from each other: and, in a relative proportion, the power of cohesion will be weakened, till a fracture ensues, and the body itself is quickly broken in all its parts. If the external force be only sufficient to produce such a curvature on the body that when it is withdrawn it will recover its former state, it is clear that this strain may be repeated as often as is required, and that the body which has withstood it once, will always withstand it. It should be borne in mind, however, that we here speak only of *occasional strains*, for it is a fact no less well known than important, that a body will not suffer a permanent strain of more than one half of what it will bear when first imposed.

In stretching and breaking fibrous bodies, though the visible extension is frequently very considerable, it does not solely arise from the increasing the distance of the particles composing the cohering fibre, but is chiefly occasioned by drawing the crooked fibre straight. In this respect a great diversity prevails, as well as in the powers required to withstand a strain. In some woods, such as fir, the fibres on which the strength most depends, are very straight, and woods of this nature, it should be remarked, are generally very elastic, and break abruptly when overstrained; others, as oak, have their resisting fibres very crooked, and stretch very sensibly when subjected to a strain. These kinds of woods do not break so suddenly, but exhibit visible signs of a derangement of texture.

With respect to the *absolute force*, it seems hardly necessary to mention, that the trunk of a tree is formed of numerous longitudinal fibres, which, by annual growth, are formed in rings, or nearly in the form of concentric circles. These, by their united force of cohesion, resist separation, and the strength, therefore, is proportioned to the area of the section opposed to the resisting force.

Muschenbroëk's Experiments.

e following are a few useful facts concerning the tenacity of :—It is generally agreed that the heart of a tree is the weakest and that this weakness increases with the age of the tree. The denied by Buffon, who, however, does not prove his assertion.

e outer fibres, called the blea, are also weaker than the rest.

e wood is stronger in the middle of the trunk, than at the root,* springing of the branches, and the wood of the branches is r than that of the trunk.

e wood on the northern side of European trees is weaker than st, and that on the southern is the strongest.

heart of a tree is never in its centre, but always nearer the side, and the annual plates are consequently thinner on that The tree is strongest where the annual plates are thickest; the of which is, that the trachea, or air-vessels, which form the se- on between these plates, are weaker than the simple ligneous

m the experiments of Muschenbroëk we have some useful in- tion as to the absolute strength of different woods. They were med into convenient slips, and part of the slip was cut away to allelepiped, one-fifth of an inch square, and therefore the y-fifth part of a square inch in section. The following is the table hich the number of pounds denotes the absolute strength of a re inch.

	Pounds.
Locust tree	20100
Jujeb	18500
Beech and Oak	17300
Orange	15500
Alder	13900
Elm	13200
Mulberry	12500
Willow	12500
Ash	12000
Plum	11800
Elder	10000
Pomegranate	9750
Lemon	9250
Tamarind	8750

uffon, however, says, in contradiction to this, that healthy trees are uni- ly strongest at the root end.

Muschenbroëk's Experiments.

	Pounds.
Fir	8330
Walnut	8130
Pitch pine	7650
Quince	6750
Cypress	6000
Poplar	5500
Cedar	4880

It should be observed that the writer assigns a much greater tenacity to these woods than others who have treated on the subject; the reason for the great difference however is, that he gives the weight that will just tear them asunder; while others, as Mr. Emerson, give that which may be suspended to them with safety.

Muschenbroëk, gives a very minute detail of his experiments on the ash and walnut, in which he states the weights required to tear asunder slips taken from the four sides of these trees, and on each side, in a regular progression from the centre to the circumference. The numbers in the foregoing table corresponding with these two woods may be considered, therefore, as the average of more than fifty trials of each. He mentions also that all the other numbers were calculated with the same care. For these reasons some confidence may be placed in the results; though they carry the degrees of tenacity considerably higher than those enumerated by some other writers. This gives 8640 for the greatest strength of a square inch, which is much inferior to Muschenbroëk's calculation. To the foregoing table may be added:—

	Pounds.
Ivory	16270
Bone	5250
Horn	8750
Whalebone	7500
Tooth of sea calf	4075

These numbers express something more than the utmost attraction of cohesion, the weights are such as will very quickly, (that is in a minute or two,) tear the rods asunder. In general it may be observed, that two-thirds of these weights will greatly impair the strength after a considerable time, and that one half is the utmost that can remain suspended at them, without incurring the risk of their demolition; and on this calculation of one-half of the nominal weight, the en-

should reckon in all his constructions; though, even in this , there are great shades of difference. Woods of a very straight uch as fir, will suffer less injury from a load which is not suf- to break them immediately.

Emerson mentions the following as the weights, or loads, may be safely suspended to an inch square, of the several bodies er enumerated.

	Pounds.
Iron	76400
Brass	35600
Hempen Rope	19600
Ivory	15700
Oak, Box, Yew, and Plum tree	7850
Elm, Ash, and Beech	6070
Walnut and Plum	5360
Red fir, Holly, Elder, Plane, and Crab	5000
Cherry and Hazel	4760
Alder, Asp, Birch, and Willow	4290
Lead	430
Freestone	914

ingenious gentleman has laid down as a practical rule, that a r whose diameter is six inches, will carry, when loaded to one- of its absolute strength, as follows:—

	Cwt.
Iron	135
Good rope	22
Oak	14
Fir	9

have next to consider the *compression* of timber: theoretically g, the positive strength of a body suffering under compression r a relative proportion to the area of its section: it is abso- mpossible for a piece of timber to be so straight, and the weight upon it so equally disposed, as to press in a direction precisely licular upon each fibre. If therefore we conceive the smallest cting transversely it will be easily imagined that the length e much to do with the strength.

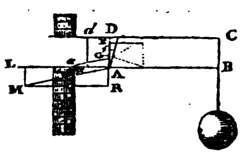
nt has shown that the force required to crush a body, is nearly o that which will tear it asunder. He observes, also, that it s something more than sixty pounds on every square line, to piece of sound oak; but this rule is by no means general

Glass, for instance, will carrry a hundred times more on it than oak in this way, but will not bear suspended above four or five times as much. Oak will suspend a great deal more than fir, but fir, as a pillar, will carry twice as much. Woods of a soft texture, although they may be composed of very tenacious fibres, are more easily crushed by the load upon them. The softness of texture is chiefly owing to the crooked nature of their fibres, and to the existence of considerable vacuities between each fibre, so that they are more easily bent in a lateral direction and crushed. When a post is overstrained by its load, it is observed to increase sensibly in diameter.

The first author who has considered the compression of columns with attention, is the celebrated *Euler*, who published in the Berlin Memoirs for 1757, his theory of the strength of columns. The general proposition established by this theory is, that the strength of prismatic columns is in the direct quadruplicate ratio of their diameters and the inverse ratio of their lengths. He prosecuted this subject in the Petersburgh Commentaries for 1778, confirming his former theory. *Muschenbroek* has compared the theory with experiments, but the comparison has been very unsatisfactory, the experiments neither confirming nor positively negativeing the theory.

The next and most common strain to which bodies are exposed, is that which tends to break them across.

In strains of this kind it frequently happens, that the power of a lever is exerted in addition to the positive force of the strain.



Let ABCD, in the above diagram be supposed to represent the vertical section of a prismatic solid, projecting horizontally from a wall in which it is firmly fixed; and let a weight be hung on it at B, or let any power act at B, in a direction perpendicular to AB. —Let this body also be considered to possess insuperable strength in every part, except in the vertical section D A, perpendicular to its length, in which section only it must break.—Let the cohesion be uniform throughout the whole of this section; that is, let each of the adjoining particles of the two parts cohere with an equal force f.

There are two ways in which it may then break. The part A B C D, may simply slide down along the surface of the fracture, provided the power acting at B, be equal to the accumulated force which is exerted by every particle composing the section, in the direction A D. But let this be supposed as effectually prevented by something supporting the point A. The action at P, tends to make the body turn round A (or round a horizontal line passing through A at right angles with A B) in the same manner as round a joint. This it cannot do without separating at the line D A, in which case the adjoining particles at D, or at E, will be separated horizontally. But their attraction of cohesion resists this separation. In order, therefore, that the fracture may happen at the place intended, the energy of the power P, acting by means of the lever A B, must be superior to the accumulated energies of the component particles. The energy of each depends not only on its cohesive, or connecting force, but also on its peculiar situation; for the supposed insuperable firmness of the rest of the body, renders it a lever turning round the fulcrum A, and the individual cohesive power of each particle, such as D or E, acts by means of the arm, D A or E A. The precise energy of each particle will consequently be ascertained by multiplying the force individually exerted by it at the moment of fracture, by the arm of the lever which enables it to act.

Let us then suppose that, at the moment of fracture, every individual particle exerts an equal force f. The energy of D, will be D A $\times$ f, that of E will be E A $\times$ f, and that of the whole will be the sum of all these products. Let the depth D A, of the section, be called d, and let any undetermined part of it, as A E, be called x, then the space occupied by any particle will be $\dot{x}$. The cohesion of this space may be represented by f $\dot{x}$, and that of the whole by f d. The energy by which each element $\dot{x}$, of the line D A, or d, resists the fracture, will be f x $\dot{x}$, and the whole accumulated energies will be f $\times \int x\dot{x}$. This is well known to be f $\times \frac{1}{2}$ d^2, or f d $\times \frac{1}{2}$ d. It is the same thing, therefore, as if the cohesion f d, of the whole section had been concentred together at the point G, which is in the middle of D A.

This instance recals to the mind the curious and intricate problem of the *elastic curve* first investigated by the celebrated James Bernouille.

The elastic curve cannot be a circle, but becomes gradually more incurvated, in proportion as it recedes from the point where the straining forces are applied. At this point it has no curvature, and if the bar were extended even beyond this point, still there would be no

curvature. In conformity with this principle, when a beam is supported at the ends, and loaded in the middle, the curvature is greatest in the middle: but at the props, or beyond them, if the beam extend farther, there is no curvature. Therefore, when a beam projecting twenty feet from a wall, is bent to a certain curvature at the wall, by a weight suspended at the end, and a beam of the same size projecting twenty feet, is bent to the very same curvature at the wall, by a greater weight, at ten feet distance, the figure and the mechanical state of the beam in the vicinity of the wall, is different in these two cases, though the curvature close to the wall is the same in both. In the former case every part of the beam is incurvated; in the latter, all beyond the ten feet, is without curvature. In the former case the curvature at the distance of five feet from the wall, is three-fourths of the curvature at the wall; in the latter, the curvature at the same place, is only one half of that at the wall. This circumstance must tend to weaken the long beam, throughout the whole interval of five feet, because the greater curvature results from the greater extension of the fibres.

In the next place, we may remark, that a certain determinate curvature being suitable to every beam, it cannot be exceeded without breaking it; since two adjoining particles are thereby separated, and an end is put to their cohesion. A fibre can be extended only to a certain degree of its length. The ultimate extension of the outer fibres, must bear a certain proportion to its length, and this proportion is similar in the point of depth, to the radius of ultimate curvature, which is, therefore, determinate. Consequently, a beam of uniform breadth and depth, is most incurvated where the strain is greatest, and will necessarily break in the most incurvated part. But by changing its form, so as to render the strength of its different sections in the ratio of the strain, it is evident that the curvature will be the same throughout, or that it may be made to vary according to any law.

Du Hamel made assiduous researches into the compressibility of bodies, which tended to confirm the observation of an eminent philosopher; "that the power of resisting a transverse strain is diminished by compressibility, and so much the more diminished as the stuff is more compressible."

Du Hamel, took sixteen bars of willow, two feet long, and half an inch square, and after supporting them by props under the ends, he subjected them to the operation of weights suspended at the middle. Four of them were broken by weights of forty, forty-one, forty-seven, and fifty-two pounds; the mean of which is forty-five pounds. He

then cut through one-third of four of them, on the upper side, and filled up each cut, with a thin piece of harder wood stuck in tolerably tight. These several pieces were then broken by weights of forty-eight, fifty-four, fifty and fifty-two pounds; the mean of which is fifty-one pounds. Four others were then cut through one half, and broken by forty-seven, forty-nine, fifty and fifty-six pounds; the mean of which is forty-eight pounds. The other four were cut through two-thirds, and their mean strength was forty-two pounds.

At another time Du Hamel took six battens of willow thirty-six inches long, and one and a half square; after suitable experiments, he found that they were broken by 525 pounds at a medium.

Six bars were next cut through one-third, and each cut was filled with a wedge of hard wood stuck in with a little force, these were broken by 551 pounds on the average.

Six other bars were broken by 542 pounds on the medium, when cut half through, and the cuts were filled up in a similar manner.

Six other bars were cut three-fourths through, and broken by the pressure of 530 pounds on a medium.

A batten was cut three-fourths through, and loaded until nearly broken, it was then unloaded, and a thicker wedge was introduced tightly into the cut, so as to straighten the batten, by filling up the space left by the compression of the wood, when the batten was broken by 577 pounds.

From these experiments we may perceive, that more than two-thirds of the thickness, we may perhaps with safety say nearly three-fourths, contributed nothing to the strength. From hence, we see also, that the compressibility of bodies has a very great influence on their power of withstanding a transverse strain. We may observe, likewise, that in this most favourable supposition of equal dilatations and compressions, the strength is reduced to one half of the value of what it would have been, had the body been incompressible; and, although this may not seem obvious, at first sight, yet it will readily appear when the case is considered. In the instant of fracture, a smaller portion of the section exerts its actual cohesive forces, while a part of it serves only as a fulcrum to the lever, by whose means the strain on the section is produced; and we may further perceive, that this diminution of strength does not depend so much on the sensible compressibility, as on the proportion it bears to the power of being dilated by equal forces. The foregoing experiments on battens of willow, moreover shew, that its compressibility is very nearly equal to its dilatability.

Belidor's Experiments.

The most complete series of experiments that has been made on the positive transverse strength of timber, is to be found in Belidor's "*Science des Ingenieurs.*" The following table contains the result of his experiments, which were made on oak, of equal quality and well seasoned.

For the purpose of determining with exactness the average strength of the wood, three pieces of each dimension were tried.

The column B contains the breadth of the pieces in inches; the column D the depth; L the length; P the number of pounds which broke each piece, and M the mean weight.

	B	D	L	P	M
Experiments 1st, ends loose	1	1	18	400 415 405	406
Experiments 2d, ends firmly fixed	1	1	18	600 600 624	608
Experiments 3d, ends loose	2	1	18	810 795 812	805
Experiments 4th, ends loose	1	2	18	1570 1580 1590	1580
Experiments 5th, ends loose	1	1	36	185 195 180	187
Experiments 6th, ends fixed	1	1	36	285 280 285	283
Experiments 7th, ends loose	2	2	36	1550 1620 1585	1585
Experiments 8th, ends loose	$1\frac{2}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660

By comparing the first experiment with the third, the strength appears proportional to the breadth, while the length and depth of each piece are the same.

By comparing the first and fourth experiments together, the strength appears as the square of the depth nearly, while the breadth and length are the same.

By comparing the first and fifth experiments together, the strength appears to be nearly as the lengths, inversely, while the breadth and depth of each piece are the same.

By comparing the fifth and seventh experiments together, the strengths appear to bear a near proportion to the breadth, multiplied by the square of the depth, while the length is the same in both.

By comparing the first and seventh experiments together, the strengths are shewn to be as the square of the depth, multiplied by the breadth, and divided by the length. Experiments the first and second shew the increase of strength acquired by fastening the ends, to be in the proportion of two to three. Experiments the fifth and sixth demonstrate the same thing.

It is necessary to observe, that the cause of the irregularity always to be found in these experiments, is the texture of the timber, which, as has before been noticed, consists of annual coats, the cohesion of which to each other is far weaker than that of the fibres themselves. To illustrate this, suppose two battens, of which the sections are oblong parallelograms, to be cut out of a tree, the one having these coats disposed transversely on its section, the other longitudinally: the latter will be so much stronger than the former, as a series of planks set edgeways, is stronger than the same plates horizontally disposed. Buffon says, that the one is to the other as eight to seven, but it is feared that he was not careful that the bars had their plates all disposed the same way.

We have now to detail the result of the experiments of M. de Buffon.

This ingenious philosopher prosecuted, during two years, a variety of experiments on small battens of oak. He found, however, from these experiments, that the variation in a single layer, or in part of a layer, either more or less, or even a different disposition of them, had so much influence that he was under the necessity of abandoning the method, and proceeding to operate on the largest beams that he could possibly break. The annexed table shews a series of experiments on bars of sound oak, four inches square, and free from knots.

1	2	3	4	5
7	60 56	5350 5275	3·5 4·5	29 22
8	68 63	4600 4500	3·75 4·7	15 13
9	77 71	4100 3950	4·85 5·5	14 12
10	84 82	3625 3600	5·83 6·5	15 15
12	100 98	3050 2925	7 8	

The first column exhibits the length of the bar, in clear feet, between the supports.

The second expresses the weight of the bar in pounds, on the second day after it was felled, as evinced by experiments performed on two bars of each sort. Each of the first three pairs consisted of two cuts of the same tree. The one next the root was always found to be the heaviest, and Buffon uniformly observed, that the heaviest was constantly the strongest, and recommends this particular, as a sure rule for the choice of timber. He observes, also, that this always proved to be the case when the timber, by growing vigorously, had formed very thick annual layers; but this circumstance takes place only during the advances of the tree to a state of maturity, because the strengths of the different circles approach in a gradual manner to equality, during the tree's healthy growth, when they decrease in these parts in a contrary manner.

The third column, represents the number of pounds required to break the tree, in the course of a few minutes.

The fourth column, points out the number of inches in which a tree bends down before breaking.

The fifth column, shews the time at which it broke.

The experiments made on other sizes, were conducted in a similar way. All the beams were formed square, and their sizes in inches are signified at the head of the columns, in the following table. In the first column are expressed their lengths in feet.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14		5300	7475	13225	19775	5763
16		4350	6362	11000	16375	5042
18		3700	5562	9245	13200	4482
20		3225	4950	8375	11487	4034
22		2975				3667
24		2162				3362
28		1775				2881

[. Buffon, in order to effect uniformity in his experiments, had all :rees felled in the same season of the year, squared the day after, operated on the third day, when he found also, that the strength ık timber diminished much in the course of drying.—After a piece ıis green timber had been placed in the situation required for the :riment, and weights nearly sufficient to break it were applied briskness, a very sensible smoke was perceived to issue from its ends, with a sharp hissing noise, which continued during the le of the time the tree was bending and cracking. This result eniably proved, that the whole length of the tree was strained, ch may be inferred, indeed, from its bending through its whole th;) and, nothing, perhaps, could evince in a stronger manner, powerful effects of compression.

[. de Buffon considered the experiments on the five-inch bars as standard of comparison, having both extended these to a greater th and tried more pieces of each length.

'f the strength of other kinds of timber besides oak, we have no :riments on record. With respect to fir, indeed, Buffon says it esses three-fifths of the strength of oak: but the assertion is un-)orted by any known facts, and Parent assigns to it five-sixths. countryman Emerson differs from both, and gives it two-thirds.*

[. Buffon uniformly found two-thirds of the weight which broke a n at once, sensibly impaired its strength, and produced a fracture ıe end of two or three months. One half usually brought it to a ain curvature, which did not increase after the first minute or two, might be borne by the beam for any length of time.

One-third seemed to have no permanent effect upon the beam which recovered its rectilineal shape completely, even after it had been loaded several months, provided the timber was seasoned when first loaded; that is to say, one-third of the weight which would quickly break a seasoned beam, or one-fourth of what would break one in its green state, may lie on it for ever without injury.

The agreement of the numbers found by the rule of the breadth being multiplied by the square of the depth, appears to deviate less from the experiments of Buffon, than that of the inverse ratio of the length; but even this rule applied to softer woods will differ considerably from the truth: which will be evident when we consider that a beam just breaking, will be strongly compressed on the side nearest the axis of fracture, and the opposite side will be greatly extended: consequently there must be some point between the fulcrum and the opposite side, which will neither be extended nor compressed, and all the fibres lying between this point and the fulcrum, being in a state of compression, have therefore little resistance in preventing the fracture; those fibres only on the other side being exerted.

We come now to the fourth and last strain to which timber can be subjected; namely, the being wrenched or twisted, the principal objects of which are the axles of wheels.

A cylinder may be twisted so powerfully, that the particles situated in the exterior circumference must lose their cohesion, when it will be wrenched asunder by all the inner circles giving way in succession. If we admit this, then a body, the texture of which is homogeneous, will resist a simple twist with two-thirds of the force with which it would resist it, if an attempt were made to force it asunder laterally, or with one-third part of the force which will cut it by a square edged tool.

When two cylinders are wrenched asunder, we must of necessity conclude that the external particles of each are placed just beyond their limits of cohesion, that they are extended equally, and operate with equal forces: whence it follows, that at the instant of fracture the entire sum of the forces actually exerted, is as the squares of the diameters.

We may next refer to some observations and examples of that ingenious experimental philosopher Mr. John Banks, contained in his useful treatise on the "*Power of Machines*," which work we strongly recommend to the attention of mechanics in general.

This gentleman commences with "Rules and observations respecting the form and strength of beams of wood and iron for supporting weights, working engines, &c.

"If the materials of which different beams are made, be equally good, the comparative strength under any regular form may easily be investigated. But we find by experiment that the same kind of wood, and of the same form and dimensions, will break with very different weights; or, one piece is much stronger than another, not only cut out of the same tree, but out of the same rod; or, a piece of a given length, planed equally thick, and cut in two or three pieces, these pieces will be broken with different weights. Iron also varies in strength, and not only from different furnaces, but from the same furnace, and the same melting; but this seems to be owing to some imperfection in the casting, and in general iron is much more uniform than wood. The resistance which any beam of wood or iron affords, will be as the sum of the products of all the fibres, between the top and bottom, multiplied by their respective distances from the top. For if a=length, b=breadth, and z=depth, we shall have $z \times \dot{z}$, and divided by $\frac{a}{2}$; the fluent of $z\dot{z}=\frac{z^2}{2}$; hence, $\frac{bz^2}{2}=$ the whole resistance, which when the weight is suspended from the middle of the beam, must be divided by half the length, or by $\frac{a}{2}$, which will be equal to $\frac{bz^2}{a}$; which expresses the strength of the beam. From which we have the following

Rule.—" *Multiply the breadth in inches by the square of the depth in inches, and divide that product by the length in inches, the quotient is a fraction, or whole number, &c. which expresses the comparative strength of the beam.*

"The dimensions may be taken in feet, or the breadth and depth in inches, and the length in feet, but to compare one piece with another they must all be taken in the same manner. From a great number of experiments which I have made on the strength of wood, and that on pieces of various lengths and breadths, &c. I found that the worst or weakest piece of dry heart of oak, one inch square, and one foot long, did bear 660 pounds, though much bended, and two pounds more broke it. The strongest piece I have tried of the same dimensions, broke with 974 pounds.

"The worst piece of deal I have tried, bore 460 pounds, but broke with four more. The best piece bore 690 pounds, but broke with a little more. These pieces were one inch square, and one foot long.

Example 1.—" Given a piece of oak six inches square, and eight feet in length, to find what weight suspended from the middle will break it.

Solution.—" In the worst piece of oak one inch square, and twelv inches long, the strength is one squared, *viz.* the depth squared an multiplied by the breadth, and divided by the length, which is $\frac{1}{12}$. In the given piece we have six, the depth squared equal thirty-six which multiplied by the breadth (6) gives 216, which divided by th length 96, gives $\frac{216}{96}$, or, $\frac{9}{4}$; hence as $\frac{1}{12}$ is to 660 pounds, so is $\frac{9}{4}$ t 17820 pounds.

" From the above, we may compute the following weights, whicl placed opposite to the fraction or whole number, which is obtained by the rule before given, and the dimensions taken in inches; in the second column, in feet; in the third, the breadth and depth in inches, and the length in feet.

The square of the depth multiplied by the breadth and divided by the length.	Weight in pounds which will nearly break it, 1st	Dimensions taken in feet, 2d	Weight in pounds.	Breadth and depth in inches.	Length in Feet, 3d
$\frac{1}{12}$	660	$\frac{1}{1773}$	660	1	660
$\frac{1}{10}$	792	$\frac{1}{80}$	14256	$\frac{4}{3}$	880
$\frac{1}{8}$	990	$\frac{1}{60}$	19008	$\frac{5}{2}$	1650
$\frac{1}{6}$	1320	$\frac{1}{40}$	28512	3	1980
$\frac{1}{4}$	1980	$\frac{1}{30}$	38016	4	2640
$\frac{1}{2}$	3960	$\frac{1}{20}$	57024	5	3300
1	7920	$\frac{1}{10}$	114048	6	3960
2	15940	1	1140480	8	5280
3	23760			10	6600
4	31680				

THE

CARPENTER'S AND JOINER'S

COMPLETE GUIDE.

CARPENTRY AND JOINERY.

he operations of joinery consist of forming surfaces of various s, also of grooving, rebating, and moulding, and of mortising tenoning, and lastly, of joining two or several pieces together, s to form a frame or solid mass.

urfaces, in joinery, are either plane or curved, but most frequently e.

ll kinds of surfaces are first formed in the rough, and finally ght to exact forms by means of tools adapted for the purpose.

rooving consists in taking away a part of a rectangular section a piece of wood, so as to form a channel of equal breadth ighout, with three surfaces, one being parallel and the other two endicular to the surface of the wood from which the channel is ssed: the channel thus formed is called a *groove.*

ebating consists in taking away a part from a piece of wood of a ngular section, so as to leave only two sides, each of a parallel dth, the one side being perpendicular to the surface of the wood, the other parallel to it: the cavity thus formed is called a *te.* From this definition it is manifest, that a rebate can only be ed by reducing the piece of wood to be rebated at the angle itself, may therefore be looked upon as a half groove.

mortise is a cavity recessed within the surface of a piece of wood, four sides perpendicular to that surface, and likewise to each r; the act of making a mortise is called *mortising.*

A *tenon* is a projection formed on the end of a piece of wood with four plane sides, at right angles to each other, and to a plane, from which it projects; and this plane is called the shoulder of the tenon.

In the following observations, all pieces of wood whatever are supposed to be rectangular prisms, and the length in the direction of the fibres; two of the sides of every mortise to be perpendicular, and the other two sides parallel to the fibres; the four sides of every tenon in the direction of the fibres, unless otherwise stated: likewise, if two of the surfaces of a piece of wood be of greater breadth than the other two, these are called the edges and those the sides, and each line of concourse, formed by two adjacent sides, is called an *arris*.

Moulding consists in forming the surface of a piece by curved or plane surfaces, or by both, in such a manner, that all parallel sections will be similar figures, that is, their boundaries will be made all to coincide.

The first thing to be done in joinery is, to select the stuff or boards, which ought to be well seasoned for every purpose in joinery, and then line it out; and if the stuff is not already at the size, as is most frequently the case, it must be ripped out with the ripping saw, or crosscut with the hand saw, or both, as may be required. The next thing is the planing of the stuff, first upon the sides, then the edge squared, and then gauged to a breadth and thickness, should either or both be found necessary.

Two or more pieces of stuff may be fastened together in various ways by pins of wood or by nails, but in work prepared by the joiner for the use of building, pieces are more frequently joined together by making their surfaces coincide, and then plastering them over with a hot tenacious liquid called glue, and afterwards rubbing the surfaces until the glue has been almost rubbed out, and the one piece brought to its situation with respect to the other. The best work is always joined by this method.

When boards are required of greater breadth than common, several boards must be fastened together edge to edge, either by nailing them to pieces extending across the breadth, or gluing them edge to edge, or by joining pieces transversely together with small boards, tongued and grooved into the interstices.

Two pieces of stuff are joined together at right or oblique angles by mortise and tenon adapted to each other, and fastened together with glue. When a frame consisting of several pieces is required, the mortises and tenons are fitted together, and the joints glued all at one

time, then entered to their places, and forced together by means of an instrument called a cramp.

The operation of forming a given surface, by taking away the superfluous wood, is called planing, and the tools themselves planes.

The first tools used by joiners are bench planes, which generally consist of a jack plane, for taking away the rough of the saw and the superfluous wood, only leaving so much as is sufficient to smooth the surface; the trying plane, to smooth or reduce the ridges left by the jack plane, and to straighten or regulate the surface, whether it be plane or convex; the long plane, when the surface is required to be very straight; the jointer, for still greater exactness in this particular; and the smoothing plane, as its name implies, for smoothing, and giving the last finish to the work.

Besides the bench planes, there are others for forming surfaces of nearly every curve or shape, as rebating planes, grooving planes, and moulding planes.

The rabbet, or rebating plane, is used for gradually taking from a board a groove in the form of a rectangular prism. This is used in cornices and other ornamental work. Rebating planes deliver their shavings at the side instead of at the top.

The plane employed in cutting a square groove in the edge of a board, so as to leave a ridge on each side, is called a *plough*, and the operation performed by it, *ploughing*. To prevent the necessity of having various sized ploughs for any required groove, a tool of this description, called a universal plough, is made use of. The stop and fence of this instrument are moveable, and it admits different sizes of irons according to the extent of the groove required.

Moulding planes are of course as various in their appearance as the forms they are intended to produce; the figure of the sole should exactly correspond with that of the iron, and in whetting them the utmost care should be taken to preserve the contour.

To form the convex and concave surfaces of the rims of wheels, and similar work, the sole of the plane must be curved in the same form. Planes of this description are called *compass planes.* A convex compass plane is also distinguished as a *round sole* plane, and one which is concave as a *forkstaff* plane.

Planing machines are used to diminish the great manual labour of planing the surface of planks and boards of wood: in strictness, those alone should be termed planing machines, which operate to reduce the surface of the wood to a true and smooth plane, by means of planes or instruments of a similar nature, though actuated by the

power of machinery instead of the strength of a man's arm; but custom has denominated those machines which cut flat surfaces in a different manner from planes of the same description.

These machines are of modern invention; the first, we believe, was projected by General Bentham, who obtained a patent for it in 1791. It consisted of a plane, to be put in motion by means of a crank turned by a mill, to give it a reciprocating motion; or on a smaller scale it might be worked by hand in the usual manner, but the plane was so formed as to require none of the skill and attention necessary in the ordinary method of operating; here the workman, besides exerting the force necessary to impel the instrument along, has several points to attend to; even in the simple case of planing a straight board, he must adjust his tool to the board in a proper manner for beginning the stroke, and employ sufficient force to keep it down on the board; and in returning, he must raise it up off the board sufficient to save the cutting edge from injury; he must also guide it sideways to prevent it slipping off the board, and if this be wider than the plane, he must constantly examine if he reduces the middle and sides in a proper manner to make a plane surface; and lastly, he must observe the marks he previously makes for the thickness of the board, that he may keep it parallel, and not reduce it too thin. By the General's invention all these circumstances are gained at once; the planes are made the full width of the boards intended to be planed, and on each side of it fillets or cheeks are fixed, which project beneath the face of the plane just as much as the thickness the board is to be reduced to: these cheeks, therefore, guide the plane sideways in passing along the board, and gauge it in thickness; because, when the board is reduced to the quantity which the cheeks are beneath the surface of the plane, the cheeks rest upon the bench or surface on which the board lies, and bear off the plane, so that it can cut no longer. The plane is kept down by its own weight, which is increased when necessary, by loading it with weights, and these are contrived to be capable of shifting their position from one end of the plane to the other during the time it is making the stroke; because, at first the pressure is required at the fore-end to enter the cut, but at the conclusion it must be greatest at the hinder-end, to prevent the fore-end tripping down the instant it leaves the board. By another contrivance the plane is caused to rise up sufficiently to clear the cutting edge from the wood when the plane is on its return. It is by a piece which acts as a handle to the plane, and to which the power is applied, that it is fixed in the manner of a lever upon an axis extending

across the width of the plane, and carrying at each side of it a small lever, provided with rollers in their extremities; the handle projects upwards from the plane, which being forced forwards by it, assumes an inclined position, as do also the short levers, and their rollers then rise above the cheeks of the plane; but when the plane is drawn back, its handle is first drawn back into an erect position, and the levers moving with it, their rollers project beneath the cheeks of the plane, and raise it off the bench, the plane being in its return borne by them.

The bench for supporting the board during the operation was also of a peculiar construction, in order to confine the work steady upon it. In cases when the boards to be planed are winding or irregular on the lower side, so that they cannot lie flat upon the bench, it is provided with two sides, which can be brought to close upon the edges of the board, and hold it steady between them, being furnished with one or more rows of flat teeth to penetrate the wood and retain it; these sides are contrived to rise or fall upon the bench, to accommodate the different thicknesses of the boards. When a very thin board is to be planed, it might be liable to spring up to the iron, so as to be reduced even after the plane came to rest with its cheeks upon the bench; to avoid this the edges of the board are to be held by the sides to the bench above-mentioned; but as it would still be liable to spring up in the middle part, heavy rollers, or rollers loaded with weights, are fitted in apertures made in the plane as near as possible to the cutting edge, and these will keep the board down close upon the bench. For planing pieces of greater thickness at one end than the other, the cheeks of the plane are to be borne upon rollers of wood laid on the bench at each side, the wood being as much thicker at one end as the board is intended to be thinner at that end; therefore, when the plane has reduced the wood, the cheeks come to bear upon these rollers, and cause it to move, not parallel to the bench, but inclined, according as they are thicker at one end than the other: in like manner, by using them of different thicknesses at the different sides of the board may be made feather-edged.

Mr. Bramah invented a planing machine, which he has used very advantageously for planing all kinds of timber flat, at an exceedingly small expense. In 1802 he took out a patent for the invention, which he describes in his specification to consist in the following particulars. "The cutting tools employed to reduce the wood, instead of being worked by hand are to be fixed on frames, some of which are to be moved in a rotatory direction round an upright shaft, and others

have a shaft lying in a horizontal position like a common lathe. In other instances, the tools are fixed on frames, which slide in stationed grooves, to be driven also by machinery. The principal points on which the merits of the invention rest, are, 1. The materials to be wrought are made to slide in contact with the tool, instead of the tool being carried by the hand over the work in the usual way. 2. The tool is made to traverse across the work in a square or oblique direction, except in cases where it may be necessary to fix the tool in an immoveable station, and cause the work to fall in contact with it by a peculiar motion. 3. Instead of common tools, bent knives, spoke shaves, or deep cutting gouges, are used for cutting off the roughest parts, and planes of various shapes and constructions as the work may require, are applied to follow the former in succession under the same operation, and which latter I call finishers. 4. These are fixed in frames which move in cases, like those on which the saws are fixed in a sawing mill, and in other instances these frames are fixed on a rotatory upright shaft turning on a step, and carrying the frame round in a direction similar to the upper mill-stone for grinding corn, and sometimes the frames turn on a horizontal shaft, resembling the mandrel of a common turning lathe. The different planes, tools, &c. are fixed in the frames, so as to fall successively in contact with the wood or other materials to be cut, so that the cutter or tool calculated to cut the rough and prominent part operates first, and those that follow must be so regulated as to reduce the material down to the line intended for the surface. These cutter-frames must also have the property of being regulated by a screw, or otherwise, so as to approach nearer the work, or recede at pleasure, in order that a deeper or shallower cut may be taken at discretion, or that the machine may repeat its action without depressing the material on which they act. 5. When an upright shaft is used, the pivot is to turn in oil, and it may be raised or depressed at pleasure, by means of a greater or less quantity of the said fluid being confined between the end of the shaft at the bottom of the step. 6. The materials to be cut must be firmly fixed on a frame, similar to those in sawing-mills, on which the timber is carried to the saws. These frames must be moved in a steady progressive manner as the cutter-frame turns round, either by the same power which moves the latter, or otherwise, as may be found to answer best in practice. 7. The motion of the cutter-frames must be under the controul of a regulator, so that the velocity of the tool, in passing over the work, may be made quicker or slower, as such work may respectively require, to cause the cutter to act properly to the

best advantage." For this purpose Mr. Bramah proposes to use what he calls a universal regulator of velocity, and which he describes as follows: "I take any number of cog-wheels, of different diameter, with teeth that will exactly fit each other through the whole; suppose ten, or any other number, but for an example say ten, the smallest of which shall not exceed one inch in diameter, and the largest suppose ten inches in diameter, and all the rest to mount by regular gradation in their diameters from one to ten. I fix these ten wheels, fast and immoveable, on an axis perfectly true, so as to form a cone of wheels; I then take ten other wheels, exactly the same in all respects as the former, and fix them on another axis, also perfectly true, and the wheels in perfect gradation also; but these latter wheels I do not fix fast on their axes like the former, but leave them all loose, so as to turn upon the said axes, contrary to the former, which are all fixed. All these latter wheels I have the power of locking by a pin, or otherwise, so that I can at discretion lock or unite any single wheel at pleasure to the axis: I then place the two axes parallel to each other, with the wheels which form the two cones as above described, in reverse position, so that the large wheel at one end of the cone may lock its teeth into the smallest one in the cone opposite, and likewise *vice versâ*. Then suppose the axis on which the wheels are permanently fixed to be turned about, all the wheels on the other axis will be carried round with velocities correspondent to their diameters, and those of the former, but their axis will not move. Then lock the largest wheel on the loose axis, and by turning about the fastened axis, as before, it must take ten revolutions, while the opposite wheel performs but one; then by unlocking the largest wheel, and locking the smallest one at the contrary end of the cone in its stead, and turning as before, the fastened axis will then turn the opposite ten times, while itself only revolves once. Thus the axes or shafts of these cones, or conical combinations of wheels, may turn each other reciprocally, as one to ten, and ten to one, which collectively produces a change in velocity, under an uniform action of the *primum mobile*, as ten to a hundred; for when the small wheel on the loose axis is locked, and the fast one makes ten revolutions, the former will make one hundred; and by adding to the number of those wheels and extending the cones, which may be done *ad infinitum*, velocities may be likewise infinitely varied by this simple contrivance: A may turn B with a speed equal to thousands or millions of times its own motion; and by changing a pin and locking a different wheel, as above described, B will turn A in the same propor-

tion, and their powers will be transferred to each in proportion as their velocities reciprocally. Here is an universal regulator at once for both power and velocity. In some instances I produce a like effect, by the same necessary number of wheels made to correspond in conical order, but instead of being all constantly mounted on the axes or shafts, as above described, they will reciprocally be changed from one axis to the other, in single pairs, to match according to the speed or power wanted, just as in the former instance. This method will have, in all respects, the same effect, but not so convenient as when the wheels are all fixed."

The tools employed in boring cylindrical holes are, augers, a stock, with bits of various descriptions and sizes, gimlets, and brad-awls of several diameters.

The auger in most common use is like the gimlet, a kind of gouge, but terminated by a point like that of a nose bit. The inconvenience of working with this instrument is very great, since it cannot be used till a previous perforation is made in the wood, and even then till it has proceeded a considerable depth into the wood its motion is so unsteady as to require the greatest care to prevent its going astray. An improvement upon this, by Mr. Phineas Cooke, was rewarded by a premium of thirty guineas by the Society of Arts. This instrument is pointed by a worm screw like a gimlet; its body is formed by a rectangular bar of steel twisted in the shape of a bottle screw, whence it is called the spiral auger. The upper part, as in the common instrument, is formed into a large ring, in which the handle is inserted, at right angles to the body of the auger. This instrument, though possessing many advantages over the old construction, is little used, partly on account of its expense, and being apt to change its form, if the metal is not carefully tempered, particularly when used with hard woods. A later improvement will probably supersede both this and the old one. This, like the spiral auger, terminates with a gimlet screw: immediately above this it is of a prismoidal shape, tapering a little upwards: in this part it has one edge which cuts the side of the hole, and another which cuts the bottom. In the act of boring the core rises in the form of spiral shavings. The general disadvantage of augers with gimlet points is, that they are apt to break in the wood.

The next boring instrument to be mentioned is the stock and bit. The stock is a kind of crank, and is generally made of wood, defended by brass: where the crank terminates, two short limbs proceed from it, at the end of one of which is a hole to insert the piece of steel employed in boring, and at the end of the other a broad circular piece

on which the rest moves, and which, for greater convenience in working, is placed against the breast. *Bits*, which are the pieces of steel inserted in the stock, are of various forms according to their use; the gouge-bit, which is used for boring small holes in soft wood, is shaped like a gouge, but diminishing a little towards its extremity; the basil is in the inside, and the sides are brought to a cutting edge. The centre-bit has a point projecting from the lower end, which entering the wood first, preserves the instrument straight in its course.

The *countersink* is a kind of bit for widening the upper part of a hole to admit the head of a screw. Those made for brass, which consist of a cone with teeth which act as a file, are often used for wood to avoid tearing it.

The gimlet and the brad-awl are instruments too well known to need any description here.

The tools used in paring the wood obliquely, or across the fibres, and for cutting rectangular prismatic cavities, are in general denominated chisels: those for paring the wood across the fibres are called firmers, or paring chisels, and those for cutting rectangular prismatic cavities, are called mortise chisels, the rectangular cavities themselves being called mortises, when made to receive a projection of the same form and size, and by this means to fasten two pieces of wood together at any angle. The sides of all chisels, in a direction of their length, are straight, and the side of a chisel which contains the cutting edge at the end, is made of steel. The best paring chisels are made entirely of cast steel. Chisels for paring concave surfaces are denominated gouges.

Dividing wood, by cutting away a very thin portion of the material of equal thickness throughout, to any required extent, by means of a thin plate of steel with a toothed edge, is called sawing, and the instruments themselves are called saws, which are of several kinds, as the ripping saw, for dividing boards into several pieces in the direction of the fibres; the hand saw, for cross-cutting, and sawing thin pieces in the direction of the grain; the panel saw, either for cross-cutting, or cutting very thin boards longitudinally; the tenon saw, with a thick iron back, for making an incision of any depth below the surface of the wood, and for cutting pieces entirely through not exceeding the breadth of that part of the plate without the iron back; likewise a sash saw, and a dovetail saw, used much in the same way as the tenon saw. From the thinness of the plates of these three last saws, it is necessary to stiffen them by a strong piece of metal called the back, which is grooved to receive the upper edge of the plate that is fixed to the

back, and which is thereby secured and prevented from bending. When it is required to divide boards into curved pieces, a very narrow saw without a back, called a compass saw, is used, and in cutting a very small hole, a saw of a similar description, called a key-hole saw, is employed. All these saws have their plates longer and thinner, and their teeth finer, as they succeed each other in the order here mentioned, excepting the two last, which have thicker plates and coarser teeth than either the sash or dovetail saw. The external and internal faces of the teeth of all saws are generally formed at an angle of 60 degrees, and the front edge teeth slope backward in a small degree, but incline or recline from the straight line drawn from the interior angle perpendicular to the edge in the plane of the plate, as the saw may be employed in ripping, or in cross-cutting perpendicular to the fibres. The teeth of all saws, except turning and key-hole saws, are bent on contrary sides of the plate, each two teeth succeeding each other being alike bent on the different sides of the plate; *viz.* the one as much to the one side as the other is to the other side, and consequently all the teeth on the same side alike bent throughout the length of the plate for the purpose of clearing the sides of the cut which it makes in the wood.

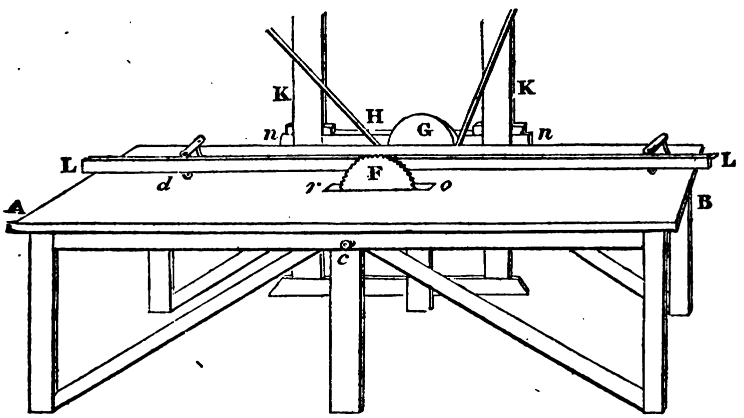
Of all cutting tools whatever, the saw is the most useful to the joiner, as the timber of wood which he employs can be divided into slips or bars of any size with no more waste of stuff than a slice, the breadth of which is equal to the depth of the piece to be cut through, and the thickness equal to the distance of the teeth between their extreme points on the alternate sides of the saw, measured on a line perpendicular to the said sides: whereas, without the use of the saw, cylindrical trees could only be reduced to the intended size by means of the axe, in the use of which there would not only be an immense consumption of stuff, but also much greater labour would be required to straighten it.

The vast quantity of labour and time expended in manual sawing, has led to the construction of mills for this purpose. The use of these machines has rapidly increased in this country within the last few years, from the successful application of the steam-engine as a moving power; and such is the perfection to which they are brought, that wood is cut by them to the thickness of writing paper. A general description of the objects to be attained by the mechanism of a saw-mill, on the largest scale, may be comprised in a few words: the saw is drawn up and down, as long as is necessary, by a motion communicated to the wheel; the piece of timber to be cut into boards is

advanced by a uniform motion to receive the strokes of the saw, for here the wood is to meet the saw, and not the saw to follow the wood, therefore the motion of the wood and that of the saw ought immediately to depend the one on the other; and when the saw has cut through the whole length of the piece, the machine should stop and remain immoveable, lest, having no obstacle to surmount, the force of the moving power should turn the wheel with too great rapidity, and break some part of the machine.

The largest apparatus of this description yet constructed was contrived by Mr. Brunell, and placed in a building in the neighbourhood of Battersea; but the most complete saw-mill was erected in the Government Yard at Portsmouth, and impelled by a large steam engine, by means of which it raised the wood to its required situation on the frame, and indeed performed all the essential functions of animal life.

Circular saws for ripping up boards or scantlings of moderate thickness, are not so generally used by artists as would be found advantageous. We shall therefore particularly notice the construction of a circular saw-mill, invented by Smart, and used in his manufactory. Like his improvement in the art of turning cylinders, it is distinguished by its simplicity and utility.



A B is a strong table made of planks firmly braced together in the form of a joiner's bench. In the middle of this bench a longitudinal opening, *r o*, admits the circular saw, F, which is made of well-tempered steel plate. G is a pully on the same axis with the saw, and a rapid motion is communicated to it by means of an endless strap from a large fly wheel, turned by horse-power. The saw is fixed on a

spindle, D, by a shoulder, *d*, against which it is held by another moveable shoulder, *e*, pressed against by a nut, *k*, screwed on the end of the spindle, which is tapped for the purpose. The hole in the centre of the saw must fit the spindle exactly, and may be either square or circular. If it be circular it must have a small notch in it, to fit a fillet on the spindle, that the saw and the spindle may revolve together. The ends of the spindle are turned off to cones, in the customary way for working in centres. The cone or point nearest the saw, works in the end of a screw, C, screwed into the bench; the other point works in a similar screw, passing through a cross-beam, H, mortised between two vertical beams, K K, extending from the floor to the ceiling. The cross-beam, H, can be raised or lowered in its mortises through the beams, K K, by wedges, *n n*, above its tenons, and two others below them. A long straight piece of wood, L L, called the guide, is connected with the bench by joints similar to those of a parallel rule. It can be set at any distance from the saw, and fixed by screws passing through circular grooves, *d d*, cut through the bench. The front of the guide, L L, must be perpendicular to the plane of the bench; and it may then be made use of to set the plane of the saw also perpendicular to the same plane. In using the machine the workman slides the end of the piece of wood to be cut against the saw as it turns round, and presses its edge against the guide, L L, at the same time, so that it may be cut straight.

When the saw is blunted by use, the centre screw, C, or that in the cross-piece, H, must be turned back; the spindle and saw can then be removed, and taking off the nut, *k*, in the figure, the saw will be loose, and another may be put on; or it may be sharpened in the same manner as any other saw while fixed in a vice. The teeth of the saw are set, that is, bent alternately on either side of the plane, and the plane of the thickness of each tooth is regulated by the direction in which it is bent. By this means the saw when cutting first takes away the wood at the two sides of the kerf, leaving an angular ridge in the middle of it, the use of which is to keep the saw steady in a right line, which might otherwise be diverted from its course by a knot, or any inequality it might meet with in the wood.

Joiners use a small axe, called a hatchet, for cutting off the superfluous wood from the edge of a piece of a board, when the waste is not of sufficient consequence to be sawn.

All the above are what are commonly denoted edge tools, but there are others required to regulate the forms. All angles whatever are formed by other reverse angles of the same number of degrees, as an

exterior angle by an interior one, and the contrary. The instrument for trying right angles is called a square, and those for trying acute or obtuse angles are called bevels. The two sides which form the edge of a square are always stationary, but those of bevels are generally moveable, one leg upon the other, round a joint.

In some cases, where a great number of pieces are required to be wrought to the same angle, a stationary bevel, called a joint hook, is used.

When it is required to reduce a piece of stuff to a parallel breadth, an instrument called a gauge is used for the purpose. The gauge consists generally of a square piece with a square mortise, through which a bar is fitted at right angles, and made to slide. The bar, which is called the stem, has a sharp point, cutter, or tooth, at one extremity, projecting a little from the surface, so that when the side of the gauge next to the end which has the point is applied on the vertical surface of the wood, with the flat side of the stem which has the tooth upon the horizontal, and pushed and drawn alternately by the workman from and towards him, the cutter will make an incision from the surface into the wood in a direction parallel to the upper edge of the vertical side on the right hand. This line, so drawn, will mark out with precision, and shew the superfluous stuff to be taken away.

When a mortise is required to be cut in a piece of wood, a gauge with two teeth is used. The construction of this instrument is the same as the common gauge; but in addition the stem has a longitudinal slider, with a tooth projecting from the end of the slider, so that the two teeth may be brought nearer, or to any remote distance from each other, at pleasure; and also to any distance from the face of the head or guide, within the reach of the stem.

When wood has been planed, and is required to be sawn across the fibres, in order to prevent the sides of the edges from being bruised, as it is necessary to be kept stationary while sawing, joiners use a flat piece of wood with two projecting knobs on the opposite sides, one at each end, called a side hook. The vertical side of the interior angle of one of the knobs is placed close to the vertical side of the wood, and the under side on the top of the bench; then the wood is pressed against the knob which projects from the upper surface while it is cutting with the saw: but the use of the two side hooks is better, as they keep the piece of wood to be sawn more steady.

When it is required to cut a piece of wood to a mitre with one side, that is, to half a right angle, a trunk of wood is used with three sides, like

a box without ends, or a top, the sides and bottom being parallel pieces, and the sides of equal heights: through each of the opposite sides is cut a kerf in a plane, perpendicular to the bottom, at angles of 45 and 135 degrees, with the planes of the sides; and another kerf is made in the same manner, so as to have its plane at right angles to the former. The trunk thus constructed is called a mitre box. When the wood is to be cut, the mitre box is fixed firmly against the side hooks, and the piece, which is always less than the interior breadth of the mitre box, is laid within, and pressed against the farther interior angle of the mitre box, with the side downwards, to which the saw-kerf is intended to be perpendicular, and in this position is to be cut. The two kerfs in the sides of the mitre box are requisite, in order to form the acute angle on the right or left-hand side of the piece, as may be required.

When it is required to make a piece of wood straight in one direction, joiners use a slip of wood straightened on one edge, from which the slip of wood itself is called a straight edge. Its use is obvious; by its application it will be seen whether there is a coincidence between the straight edge and the surface.

When it is required to know whether the surface of a piece of wood is in the same plane, joiners use two slips of wood, straightened each on one edge, with the opposite edge parallel, and both pieces of the same breadth between the parallel edges: each piece has therefore two straight edges. Suppose it were required to know whether a board is twisted on its surface in a plane; the workman lays one of the slips across the one end, and the other across the other end of the board, with one of the straight edges of each upon the surface; then he looks in the longitudinal direction of the board, over the upper edges of the two slips, until his eye and the two upper edges of the slips are in one plane, or otherwise the intersection of the plane passing through the eye and the upper edge of the nearest slip, intersect the edge of the farther slip. If it happen as in the former case, the ends of the wood under the slips are in the same plane; but should it happen as in the latter, they are not. In this last case the surface is said to wind; and when the surface is so reduced that every two lines are in one plane, it is said to be out of winding, which implies its being an entire plane; from the use of these slips they are denominated winding sticks.

Before we can proceed to the method of bringing a rough surface to a plane, it will first be necessary to show how to make a straight edge, or ruler.

Here the joiner must not lose sight of the definitions of a straight line; *viz.* a straight line is that which will always coincide with another straight line, however applied together.

The operation of making the edge of a board straight is called, by joiners, shooting, and the edge so made is said to be shot.

Straight edges may be thus formed; plane the edges of two boards and apply them together, so that the superfices or faces of the boards be in the same plane, and if there be no cavity between the joint the edges will be straight, but if not, the faces must be applied to each other, the edges brought together, and planed and tried as before until they are found to coincide.

Another mode is, by having a plane surface given; plane the edges of a board as straight as the eye will admit of, and apply the face of it to that of the plane, and by the edge of the board draw a line; turn the board over with the other side upon the plane, and bring the planed edge to the line drawn before, and the extremities of the edges to their former places, and draw another line; then, if all the parts of this line coincide with the former line, the edge is already straight, but if not, repeat the operation as often as may be found necessary.

Another mode is, to plane the edge of a board as straight as the eye will admit; then plane the edge of another board until it is made to coincide with the former; take a third board, and plaue the edge of this in like manner, by making it coincide with the edge of the first board; apply the edges of the two last boards together; if they then coincide, the operation is at an end, but if not, repeat it as often as may be required.

By any of the methods now shewn, the superfices of the boards to be shot are supposed to be parallel planes, not very distant from each other; for if the faces be not parallel, or if the thickness be considerable, the operation will be the more liable to error.

To reduce the rough surface of a body to a plane.—This will not be very difficult, when it is known that a plane is that which will every where coincide with a straight line.

The most practical methods are the following: Let the workman provide two winding sticks, and apply them as before directed, making the ends out of winding, if they are not found to be so; then if all the parts of the surface are straight on which the edge of the winding sticks were placed, it is evident that the whole surface must be plane. If the surface is hollow between the said lines, one of the ends, or both, must be planed lower, until the surface acquires a small con-

vexity in the length, and then, if straightened between the straight lines at the ends, it will be a perfect plane

Another mode of forming a plane surface is of a quadrilateral form: apply a ruler along the diagonals, then if they are straight they are in a plane, but if they are both hollow, or both round, the surface to be reduced is either concave or convex, and must be straightened in these directions accordingly; and lastly, if by trying across the diagonals with the straight edge it be found that one is hollow and the other round, the surface of the board winds. In this case, bring down the protuberant part of the convex diagonal, so as to be straight with the two extremities: then straighten the concave diagonal, by planing either of the two ends, or both of them, according as the thickness of the board will require. Both diagonals being now straight, traverse the wood, that is, plane it across the fibres until all the protuberant parts between the diagonals are removed, then the workman may proceed to smooth it by working it in the direction of the fibres.

To join any number of planks together so as to form a board of a determinate breadth, the fibres of each running longitudinally with those of any other.—Shoot the two edges that are to be joined; turn the sides of the boards towards each other so that the edges that are shot may be both uppermost; spread these edges over with strong glue of a proper consistence, made very hot; one of the boards being fixed, turn the other upon it, so that the two edges may coincide, and that the faces may be both in the same plane; rub the upper one to and fro in the direction of the fibres till the glue is almost out of the joint; let these dry for a few hours; then proceed to make another joint; continue to join as many boards or planks in the same manner, till the whole intended breadth be made out. If the boards or planks of which the board is to be composed are very long, the edges that are to be united would require to be warmed before a fire, and, for rubbing and keeping the joints fair to each other, three men would be found necessary, one at each extremity, and one at the middle. Boards glued together with this kind of cement will stand as long as the substance of the deals or planks composing them, if not exposed to rain or intense heat, provided that the wood has been well seasoned beforehand, and the grain be free and straight, interrupted by few or no knots. When a board which is to be exposed to the weather is to be made of several boards or planks, the cement to be used for uniting them should not be of skin glue, but of white lead ground up

with linseed-oil, so thin that the colour may be sensibly changed into a whitish cast: this kind of glue will require a much greater time to dry than skin glue. Boards to be exposed to the weather, when their thickness will admit, are, as we have already stated, frequently tongued together; that is, the edges of both boards are grooved to an equal distance from the faces, and to an equal depth, and a slip of wood is made to fit the cavity made in both: this slip should be made to fill the grooves, but ought not to be so tight as to prevent the joint from being rubbed with proper cement.

To glue any two boards together forming a given angle.—This may be accomplished either by shooting the edge of the one board to the whole of the given angle, and making the face of the other straight; then, by applying these two surfaces together, and rubbing as before, they will form the angle required: or, if the two edges are shot to half the given angle, and the edges applied together, and rubbed and set as before, the faces of the boards will form the angle required. In both these methods, when only one side of the board is to be exposed to sight, which is most commonly the case, pieces of wood, called blocks, are fitted to the angle, and the sides glued across the joint or legs of the angle being previously planed for that purpose.

To form wooden architraves for apertures by gluing longitudinal pieces together.—Architraves may be formed out of the solid pieces, but as their formation in this way is attended with a waste of both stuff and time, the more eligible method is, to glue the parts longitudinally together, as is best adapted to the nature of the mouldings. Architraves of the Grecian form, for doors and windows, generally consist of one or two faces in parallel planes, the one of which recedes only in a small degree from the other, while the outer is terminated by mouldings which have a very prominent protection. In this case, make a board of sufficient thickness, and in breadth equal to the breadth of the architrave; prepare a slip of wood of sufficient thickness and breadth for the mouldings on the outer termination of the architrave; glue this slip upon the face close to the edge of the board, with the outer edge flush with it. In the operation two men at least will be required to rub the slip to a joint with the board; and as it often happens that the side of the slip which is to be attached to the surface of the board is considerably bent, the slip is nailed down to the board; but previously, small square pieces of wood, called buttons, are bored with holes, one in each, and a nail is put through the hole to the head; then the slip is also bored with a brad-awl, and the nails, with the pieces thus described, are entered and driven

home as far as the buttons will permit. The buttons may be about three-quarters of an inch thick, and the other two dimensions each equal to, or something more than, the breadth of the slip. The slip is sometimes grooved, and the edge of the board is tongued, glued, and inserted in the groove, instead of the above method. Sometimes, also, the two faces are made of different boards, tongued together at their joining; then the whole is afterwards struck into mouldings.

To form the surface of a cylinder with wood, whose fibres are in planes perpendicular to the axis of the cylinder, such as may be used in circular work, or the soffits of windows.

Method 1.—When the dimensions of the cylindric surface parallel to the axis, is not broader than a plank or board: this may be done by bending and gluing several veneers together, and the first upon a mould or bracket, the edges of which are in the surface of the proposed cylinder parallel to its axis.

This may be accomplished by means of two sets of brackets fixed upon a board, with a hollow cylindric space between them, of sufficient thickness for taking in the veneers, and double wedges for confining them. If this operation is carefully done, and the glue properly dried, the wedges may be slackened, and the cylindric part so glued up will be found to stand very well; but it must be observed, that, as the wood has a natural tendency to unbend itself, the curved surface upon which it is glued should be somewhat thinner than that intended to be made.

Some workmen take another method, by forming a hollow cradle, and bending the veneers into it, and confining their ends with wedges, which compress them together; then by a very small degree of rubbing, with a hammer made for this purpose, the glue will be forced out of the joint.

Another method is, to form a cradle or templet to the intended surface, and lay a veneer upon it; then glue blocks of wood upon the back of it, closely fitted to its surface, and the other joints to each other, the fibres of the blocks corresponding with those of the veneer.

A third method is, to make a cradle and place the veneers upon it, confining one end of them; spread in the glue between the veneers with a brush, and fix a bridle across, confining the ends of this bridle either by nails or by screws; open the veneers again and put in glue a second time between each two, and fix another bridle across them; proceed in this manner to another extremity.

A fourth method is, to run a number of equi-distant grooves across

back of the board, at right angles to its edges, leaving only a small :kness towards the face; let this be bent round a cradle or templet le on purpose, and let the grooves be filled with slips of wood, ich, after the glue is quite dry, are to be planed down to the sur- of the cylindric board, which may be stiffened with canvass glued oss the back.

nstead of using a grooving plane, workmen frequently make kerfs the saw, but this is not so strong when finished, as it is very dif- lt to insert the slips, and very uncertain as to the depth of each of kerfs, which will occasion a very unequal bending of the board, if y are not to a regular depth.

'o bend a board so as to form the frustrum of a cone, or any seg- ntal portion of the frustrum of a cone, such as the soffit of the d of an aperture.—Find the form of a covering according to the metrical principles of carpentry; cut out a board to this form, run a number of equidistant grooves across it tending to the tre: this being fixed to a templet made to the surface of a cone, ceed and finish it in the same manner as in the last method shewn a cylinder.

'o bend boards so as to form a spherical surface.—Make a mould to covering of a given portion of the sphere in plano, according to geometrical principles of carpentry; complete the number of res by this mould; make a templet or mould to a great circle of sphere; groove each of the staves across, at right angles to a line sing through the middle, and bend it round the templet; put slips the grooves; lastly, shoot the edges of the staves so as to be in nes tending to the centre of the sphere: these staves being glued ether will form a spherical surface.

'o glue up the shaft of a column.—Describe two circles, of neters equal to those of the superior and inferior end of the shaft. 'ircumscribe these by polygons, consisting of the same number of ilar sides as the column is to consist of staves.

'rom the angles draw lines to the centre, which will give the bevels working the edges of the staves. In this process, after two pieces glued together and dried, proceed to glue a third piece in the ie manner, and so on to the last but one. Previously to the last ig glued, the blocks should be fixed upon it, and then the whole y be closed in. It may be proper to state that the number of staves uld be eight or twelve, otherwise the joint will fall in the middle he flutes, which should not be the case. It is a very good method

to diminish the staves previous to their being glued together, as otherwise the waste of stuff would be very great.

To glue up the base of a column in several horizontal courses or rings, in order to be turned in a lathe.—Consider the number of horizontal or bevel joints which are best made at the internal angles of the mouldings; prepare a board so as to have a plain surface; let a circle be described on the plane of a diameter, equal to the diameter of the greatest circle in the height of the course, and circumscribe a regular polygon about the circle, with as many sides as there are to be pieces in a course, and from the angles draw lines towards the centre; then any radial line and the adjacent side of the polygon will form the angle by which the ends of every two pieces that are to form the course will meet, so as to make their planes coincide. The geometrical part being thus finished, prepare the pieces, each in length equal to the side of the polygon, with an acute angle at each end from the outer side, equal to the aforesaid angle on the board, so that each piece will have a longer and a shorter side: apply the longer side of each piece to the polygon, the shorter side being next to the centre, so that one of the ends may coincide, and thus the whole will meet together if the work be true. But as this is difficult, it is common to allow the pieces to be a little longer, in order to plane them, so as to make close work: for though the methods be true, the workman, though ever so careful, cannot work to geometrical exactness; since even the thickness of a shaving, or the smallest degree of twist in the board, will spoil the work. Suppose the course completely jointed, take the whole to pieces, glue the surfaces which are to meet each other, and rub each two adjacent pieces to a joint, until the whole ring or course is firmly closed. When the glue is dry, plane the upper side truly; take the radius of the greatest projecting member in the next course, and describe a circle on the top of the course, having its centre vertical to that of the lower circle; then with the centre of this circle, in the plane of the top of the course, bisect any one of the arcs comprehended between two adjacent joints, and from the point of bisection divide the circumference into as many equal parts as there are pieces in the under course, and draw radiating lines towards the centre; join every two nearest points in the circumference, and thus an inscribed polygon will be formed; draw lines to touch the circumference parallel to the sides of the inscribed polygon, and thus a polygon will be made to circumscribe the circle: produce the radiating lines until they meet the angles of the circumscribing

polygon, then the sides of the circumscribing polygon will be the situations of the bottom edge of the vertical outer sides of the second course, and the radiations the situations of the joints. Proceed as in the first course to adapt the pieces to their respective situations, making close work: glue each piece to its place on the lower course, and likewise the joints, and when the glue of this course is dry, its upper side may be planed true. Proceed with the uppermost course in the like manner, making the joints fall in the middle of the lengths of the pieces of the lower course, and when finished the work may be sent to the turner.

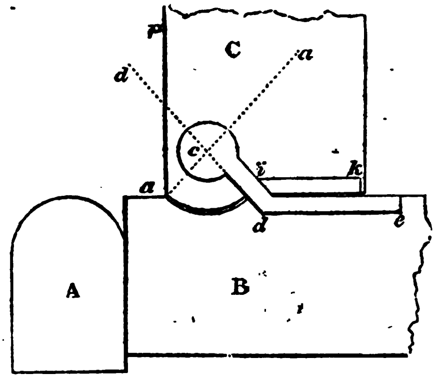
To glue up the Ionic and Corinthian capitals for carving.—The abacus must be glued in parts, in such a manner that their joints may be in vertical planes. The leaves and caulicoles of the Corinthian capital may be first made of rectangular blocks, and fixed to vans.

To make a cornice round a cylindrical body, out of the least quantity of wood, when the body is greater than a half cylinder, and concave, and when the members will nearly touch a right line applied transversely.—Draw a section of the cylinder through its axis, and let the section of the cornice be represented upon the cylindrical section. Draw a transverse line touching the two extreme members of the cornice; parallel to this line draw another line within, at such a distance from the former as may be found necessary for thickness of stuff; produce this last line until it meet the line representing the axis of the cylinder. The junction will either be above or below, according as the cornice is applied to the convex or concave sides of the cylinder. This meeting is the centre of two concentric circles, whose radii are the distances between the nearest and farthest extremes of the section of the cornice. This is evidently an application of the method of covering a cone. When mouldings are got out in this manner, *viz.* by a piece which does not occupy the space, when set to the place represented by the height and breadth, they are said to be sprung.

We now proceed to consider those essential branches of the art of joinery, the construction of doors and windows: preparatory to which, it will be necessary to explain the mode of hanging doors, &c, on hinges. As the simple attachment of a hinge is a thing so well known as to render explanation superfluous, we shall only describe cases in which great delicacy and exactness are required.

The following diagram exhibits the method of hanging a window shutter in such a manner that the hinge shall be completely concealed.

Hinge Joint.



A—Inside bead of the sash frame.

B—Inside lining.

C—Style of the shutter.

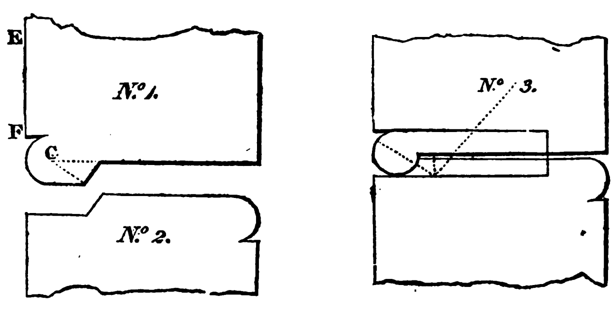
Let *a* be the intersection of the face of the shutter with that of the inside lining of the sash frame.

a k the face of the inside lining.

Bisect the angle *p a k* by the right line *a a*; now the centre *c* being determined in that line, so that the knuckle of the hinge may be at a certain distance from the face *p a* of the shutter, through *c* draw the line *d d* at right angles to *a a*; then one side of the hinge must come to the line *c d*, the hinge being made as is shewn in the figure.

To construct the jamb so as to be clear of the shutter.—From *c* as a centre, with the radius *c a*, describe the arc *a i*, which will be the joint required. In this case the strap part of the hinge may be longer on the piece to which the shutter is attached, than on the shutter itself.

To construct the joints of door styles and jambs, so that when hung together, and the door opened to a right angle, it may shew a bead to correspond with the knuckle of the hinge.



No. 1, shews the edge of a style in which a bead is constructed exactly to the size of the knuckle of the hinge, and rabbetted backwards to the depth of half the thickness of the bead.

No. 2, is the part constructed for the reception of No. 1.

No. 3, exhibits the finished joint with a common butt hinge.

The reason that a space is here left within the joint, is that room may be left for paint, which should always be provided for in work of this kind.

If it be required to hang a door in such a manner that when opened, it shall stand at a certain distance from the jamb or style to which it is thus attached; it is necessary to make the hinge project to half the distance required: the door will then, in opening, describe a part of a circle, having for its centre the knuckle of the hinge. This method is resorted to in the pews of churches, that the door when open may stand clear of the capping. When, however, circumstances do not render this necessary, the centre of the hinge should be placed within the wood, to shew as little opening as possible.

Having noticed the mode of jointing a window, it may now be advisable to notice a few important desideratem connected with this important part of a house.

The chief rules with regard to windows are, 1. That they be as few in number, and as moderate in dimensions, as may be consistent with reference to usefulness; inasmuch as all openings are weakenings. 2. That they be placed at a convenient distance from the angles, or corners of the buildings; because those parts ought not to be opened and enfeebled, whose office is to support and fasten all the rest of the building. 3. That care be taken the windows be all equal one with another, in their rank and order; so that those on the right hand may answer to those on the left, and those above be right over those below; for this situation of windows will not only be handsome and uniform, but also the void being upon the void, and the full upon the full, it will be a strengthening to the whole fabric. As to their dimensions, care is to be used to give them neither more or less light than is needful; therefore regard is to be had to the size of the rooms which are to receive the light. It is evident, that a great room needs more light, and, consequently, a greater window, than a little room; and *vice versa.* The apertures of windows, in middle-sized houses may be four and a half or five feet between the jambs; and in the greater buildings, six and a half or seven feet; and their height may be double their length at the least. But in high rooms, or larger buildings, their height may be a third, a fourth, or half their breadth, more than double their length. Such

are the proportions for windows of the first story; and according to these, must those in the upper story be for breadth; but as to height, they must diminish; the second story may be one-third part lower than the first; and the third story, one-fourth part lower than the second.

We have now to consider the construction of *doors*. With regard to their mechanical execution, which is all we have at present to do with, it is evidently an essential requisite, that in opening they should clear the carpet of the room to which they belong. For this purpose many methods have been recommended and successively adopted, without complete success having been obtained by any. We shall, however, give a list of these methods, leaving the selection to the judgment of the reader.

1st. Raise the floor under the door as much as is required.

2nd. Make the lower hinge project farther from the jamb than the upper one: in this case the two hinges must be inclined to the jamb in such a manner, that a line drawn through the centres of them both would meet the top of the door. This, however, has so ill an appearance as to be applicable only to warehouse and shop doors, and others of a similar description.

3rd. Make the jamb, to which the hinges are attached, a little out of the perpendicular; inclining inwards about one-eighth of an inch.

It requires a considerable degree of care to hang a door, a shutter, or any other piece of work in the best manner. In the hinge, the pin should be perfectly staight, and truly cylindrical, and the parts accurately fitted together.

The hinges should be placed so that their axes may be in the same straight line, as any defect in this respect will produce a considerable strain upon the hinges every time the hanging part is moved, which prevents it from moving freely, and is injurious to the hinges.

In hanging doors, centres are often used instead of hinges; but, on account of the small quantity of friction in centres, a door moves too easily, or so that a slight draft of air accelerates it so much in falling to, that it shakes the building, and is disagreeable. We have seen this in some degree remedied by placing a small spring to receive the shock of the door.

But as we have already stated, the greatest difficulty in hanging doors, is to make them to clear a carpet, and be close at the bottom when shut. To do this, that part of the floor which is under the door, when shut, may be made to rise about a quarter of an inch above the general level of the floor; which, with placing the hinges so as to cause

the door to rise as it opens, will be sufficient, unless the carpet should be a very thick one. Several mechanical contrivances have been used for either raising the door, or adding a part to spring close to the floor as the door shuts. The latter is much the better method.

Various kinds of hinges are in use. Sometimes they are concealed, as in the kind of joints called rule joints; others project, and are intended to let a door fold back over projecting mouldings, as in pulpit doors. When hinges project, the weight of the door acts with an increased leverage upon them, and they soon get out of order, unless they be strong and well fixed.

The principal object to be attended to in *stairs* is, that they afford a safe and easy communication between floors of different levels. The strength of a stair ought to be apparent as well as real, in order that those who ascend it may feel conscious of safety. In order to make the communication safe, it should be guarded by railing of proper height and strength; in order that it may be easy, the rise, and width or tread, of the steps should be regular and justly proportioned to each other, with convenient standings: there should be no winding steps, and the top of the rail should be a convenient height for the hand.

The first person that attempted to fix the relation between the height and width of a step, upon correct principles, was, we believe, Blondel, in his Cours d'Architecture. If a person, walking upon a level plane, move over a space, P, at each step, and the height that the same person could ascend vertically, with equal ease, were H; then, if h be the height of a step, and p its width; the relation between p and h must be such, that when $p = P$, $h = o$; and when $h = H$, $p = o$. These conditions are satisfied by an equation of the form of $h = H\,(1 - \frac{p}{P})$. Blondel assumes 24 inches for the value of P, and 12 inches for that of H; substituting these values in our equation it becomes $h = \frac{1}{2}(24 - p)$, which is precisely Blondel's rule. We do not think these the true values of P and H; indeed it would be difficult to ascertain them; but they are so near, and agree so well with our observations on stairs of easy ascent, that they may be taken for the elements of a practical rule. Hence, according as h or p is given we have $h = \frac{1}{2}(24 - p)$, or $p = 24 - 2\,h$.

Thus if the height of a step be six inches, then $24 - 12 = 12$ the width or tread for a step that rises six inches.

The forms of stair-cases are various. In towns, where space canno*

be allowed for convenient forms, they are often made triangular, circular, or elliptical, with winding steps, or of a mixed nature with straight sides and circular ends. In large mansions, and in other situations, where convenience and beauty are the chief objects of attention, winding steps are never introduced when it is possible to avoid them. Good stairs, therefore, require less geometrical skill than those of an inferior character. The best architectural effect is produced by rectangular stair-cases, with ornamented railing and newels. In Gothic structures scarcely any other kind can be adopted, with propriety, for a principal stair-case. Modern architecture admits of greater latitude in this respect; the end of the stair-case being sometimes circular, and the hand-rail continued, beginning either from a scroll or a newel.

Straight stairs, are such as always *fly*, that is proceed in a right line, and never wind, whence their denomination. Of these there are several kinds; as, direct fliers or plain fliers which proceed directly from one floor to another, without turning either to the right or left; these are seldom used, except for garret or cellar stairs. Square fliers, which fly round the sides of a square newel, either solid or open, having at every corner of the newel a square half step, taking up one-fourth of a circle; so that they fly from one-half step to another, and the length of the stairs is perpendicular to the side of the newel. Triangular fliers, which fly round by the sides of a triangular newel, either solid or open, having at each corner of the newel a tapering half step, taking up two-thirds of a circle; so that they fly from one half step to another; and their length is perpendicular to the side of the newel.

French fliers, which fly first directly forwards, till they come within the length of a stair of the wall; and then have a square *half pace*, from which you immediately ascend to another half pace, from which the stairs fly directly back again, parallel to their first flight.

Winding stairs, are such as always wind, and never fly; of these there is great variety; as, circular winding stairs, of which there are four kinds, viz. such as wind about a solid newel, the fore-edge of each being in a right line, pointing to the centre of the newel; commonly used in church steeples, and great old houses: such as wind round an open newel, the fore-side of each being in a right line, pointing to the centre of the newel; as those in the Monument, London: such as wind round a solid newel, only the fore-side of each an arc of a circle, either concave or convex, pointing near to the circumference of the newel; and such as resemble the other respects, save that they

have an open newel. In stairs that wind round a solid newel, the proper size is either $\frac{3}{6}$ or $\frac{1}{2}$ or $\frac{1}{4}$ or $\frac{1}{3}$ or $\frac{3}{7}$ to that of the stair-case. But if it be very small, the newel is but $\frac{3}{6.}$ In stairs that wind round an open newel, Palladio orders the newel to be one-half of the diameter of the stair-case; though there does not appear any reason why the newel here should be proportioned to the stair-case, as in the former. As to the number of stairs in each revolution; Palladio orders, that, in a stair-case six or seven feet diameter, the stairs in each revolution be twelve: if the diameter be eight, the stairs to be sixteen; if nine or ten, the stairs to be twenty; and if eighteen, to be twenty-four. Elliptical winding stairs, of which there are two kinds; the one winding round a solid, the other round an open newel: they are much of the same nature as circular stairs, excepting that, in the one, the newel is a circle, and, in the other, an ellipsis. Square winding stairs, as such as wind round a square newel, either solid or open; the fore-side of each square being in a right line, pointing to the centre of the newel. A triangular winding stairs, are such as wind round a triangular newel: the fore-side of each being a right line, pointing to the centre of the newel. Scamozzi mentions a double winding stair-case, made by Pietro del Bergo, and Jean Cossin, at Sciamberg, in France, in the king's palace. It is so contrived, as that two persons, the one ascending, and the other descending, shall never meet.

Dr. Grew describes a model of this kind of stair-case, kept in the museum of the Royal Society. The foot of one of the stair-cases, he says is opposite to that of the other; and both make a parallel ascent, and within the same cylinder. The newel in the middle is hollow, and built with long apertures, to convey light from candles placed at the bottom, and on the sides of the newel into both cases. Palladio mentions a quadruple winding stair-case, in the castle of Chamboo, near Bloys. It consists of four stair-cases, carried up together, having each its several entrance, and going up one over another, in such manner, as that, being in the middle of the building, the four serve to lead to four apartments; so that the people of the one need not go up and down the stairs of the other; yet being open in the middle, they all see each other pass. Mixed stairs are such as partly fly, and partly wind; whence some call them fliers and winders. Of these there are several kinds; as, dog-legged stairs, which first fly

directly forwards, then wind a semicircle, and then fly directly backwards, parallel to that. Square fliers and winders have a square newel, either solid or open; and fly by the sides of the newel, winding a quadrant of a circle at each corner.

The subject of *framing*, as applied to particular branches of the art, has already been noticed; a few general observations may not, however, be superfluous.

The object in framing is to reduce the wood into narrow pieces, so that the work may not be sensibly affected by shrinking; and, at the same time it enables us to vary the surface without much labour.

From this view of the subject, the joiner will readily perceive that neither the parts of the frame nor the pannels should be wide. And, as the frame should be composed of narrow pieces, it follows, that the pannels should not be very long, otherwise the frame will want strength. The pannels of framing should not be more than 15 inches wide, and four feet long, and pannels so large as this should be avoided as much as possible. The width of the framing is commonly about one-third of the width of the pannel.

It is of the utmost importance, in framing, that the tenons and mortises should be truly made. After a mortise has been made with the mortise chisel, it should be rendered perfectly even with a float; an instrument which differs from a single cut, or float file, only by having larger teeth. An inexperienced workman often makes his work fit too tight in one place and too easy in another; hence the mortise is split with driving the parts together, and the work is never firm; whereas, if the tenon fill the mortise equally, without using any considerable force in driving the work together, it is found to be firm and sound. The thickness of tenons should be about one-fourth of that of the framing, and the width of a tenon should never exceed about five times its thickness, otherwise in wedging, the tenon will become bent, and bulge out the sides of the mortise. If the rail be wide, two mortises should be made, with a space of solid wood between; the sides.

In thick framing, the strength and firmness of the joint is much increased by putting a cross or feather tongue in on each side of the tenon; these tongues are about an inch in length, and are easily put in with a plough proper for such purposes.

Sometimes, in thick framing, a double tenon in the thickness is made; but we give the preference to a single one, when tongues are put in the shoulders, as we have described; because a strong tenon is

better than two weak ones, and there is less difficulty in fitting one than two.

The pannels of framing should be made to fill the grooves, so as not to rattle, and yet to allow the pannels to shrink without splitting.

When a frame consists of carved pieces, they are often joined by means of pieces of hard wood, called keys. It is, however, a better method to join such pieces by means of a screw bolt instead of a key, the cross tongues being used whichever method is adopted.

The goodness of joiners' work depends chiefly upon the care that has been bestowed in joining the materials. In carpentry, framing owes its strength to the form and position of its parts; but in joinery, the strength of a frame depends upon the strength of the joinings. The importance, therefore, of fitting the joints together, as accurately as possible is obvious. It is very desirable, that a joiner should be a quick workman; but it is still more so that he should be a good one; that he should join his materials with firmness and accuracy; that he should make surfaces even and smooth, mouldings true and regular, and the parts intended to move, so that they may be used with ease and freedom.

Where despatch is considered as the chief excellence of a workman, it is not probable that he will strive to improve himself in his art, further than to produce the greatest quantity of barely tolerable work with the least quantity of labour. In some articles of short duration, despatch in the manufacture may be of greater importance; but in works that ought to remain firm for years, it certainly is bad economy to spare a few shillings worth of labour, at the risk of being annoyed with a piece of bad work as long as it will hold together.

We have seen, with no small degree of pleasure, the effect of encouraging good workmanship in the construction of machinery, and would recommend that a like encouragement should be given to superior workmen in other arts.

The kinds of *wood* commonly employed in joinery are, the oak, the different species of pine, mahogany, lime-tree, and poplar.

Of the oak, there are two species common in this island; that which Linnæus has named Quercus robur is the most valuable for joiners' work; it is of a finer grain, less tough, and not subject to twist as the other kind. Oak is also imported from the Baltic ports, from Germany, and from America. These foreign kinds being more free from knots, of a straighter grain, and less difficult to work, they are used in preference to our home species. Foreign oak is also much used for cabinet-work, and lately the fine curled oak, that is got from excres-

cences produced by pollard, and other old trees has been used with success in furniture. When well managed, it is very beautiful, and makes a pleasing variety. It is relieved by inlaid borders of black or white wood, but these should be sparingly used. Borders of inlaid brass, with small black lines, give a rich effect to the darker coloured kinds.

The greater part of joiners' work is executed in yellow fir, imported from the north of Europe; white fir is often used for internal work, and American pine is much used for mouldings.

Some of the West India trees afford a sort of timber, which, if it would answer in point of size, would have great advantages over any of the European wood, in ship building for the merchant-service, no worm ever touching this timber. The acajou, or tree which produces the cashew nut, is of this kind; and there is a tree of Jamaica, known by the name of the white-wood, which has exactly the same property, and so have many other of their trees.

The people who work much in wood, and that about small works, find a very surprising difference in it, according to the different seasons at which the tree was cut down, and that not regularly the same in regard to all species, but different in regard to each. The button-mould makers find that the wood of the pear-tree, cut in summer, works toughest; holly, on the contrary, works toughest when cut in winter; box is mellowest when it has been cut in summer, but hardest when cut about Easter; hawthorn works mellow when cut about October, and the service wood is always tough if cut in summer.

It is a very well known quality of metals to be longer and larger when hot, and shorter and smaller when cold; a thousand experiments prove this, and the books of experimental philosophy have sufficiently expatiated upon it; on the contrary it is found to be the property of wood, that it is longest in cold weather and shortest in hot; this change is owing to the remains of the sap yet in the wood, which being condensed by cold, is enlarged in its surface, as all liquors are, when frozen into ice, and shrinks into a less space or bulk again, when rendered liquid by heat.

It follows from this, that all wood must change its surface more or less, according as it contains more or less sap; and this may be made a test of great use for the determining what kinds of wood have most, and what least sap. This would be a very valuable piece of knowledge, since there are many uses for which that sort of wood must always serve best, which has the smallest quantity of sap remaining in it.

There is no art in which it is required, that the structure and pro-

perties of wood should be so thoroughly understood as in joinery. The practical joiner, who has made the nature of timber his study, has always a most decided advantage over those who have neglected this most important part of the art.

It is well known that wood contracts less in proportion in diameter, than it does in circumference; hence a whole tree always splits in drying. Mr. Knight has shown that, in consequence of this irregular contraction, a board may be cut from a tree, that can scarcely be made, by any means, to retain the same form and position when subjected to various degrees of heat and moisture. From the ash and the beech he cut some thin boards, in different directions relatively to their transverse septa, so that the septa crossed the middle of some of the boards at right angles, and lay nearly parallel with the surfaces of others. Both kinds were placed in a warm room, under perfectly similar circumstances. Those which had been formed by cutting across the transverse septa, soon changed their form very considerably, the one side becoming hollow, and the other round; and in drying, they contracted nearly 14 *per cent.* in width.

There is another kind of contraction in wood whilst drying, which causes it to become curved in the direction of its length. In the long styles of framing we have often observed it; indeed, on this account, it is difficult to prevent the style of a door, hung with centres, from curving so as to rub against the jamb. A very satisfactory reason for this kind of curving has been given by Mr. Knight, which also points out the manner of cutting out wood, so as to be less subject to this defect, which it is most desirable to avoid. The interior layers of wood, being older, are more compact and solid than the exterior layers of the same tree; consequently, in drying, the latter contract more in length than the former. This irregularity of contraction causes the wood to curve, in the direction of its length, and it may be avoided by cutting the wood so that the parts of each piece shall be as nearly of the same age as possible.

Besides the contraction which takes place in drying, wood undergoes a considerable change in bulk with the variations of the atmosphere. In straight grained woods the change in length is nearly insensible, hence they are sometimes employed for pendulum rods; but the lateral dimensions vary so much, that a wide piece of wood will serve as a rude hygrometer. The extent of variation decreases in a few seasons, but it is of some importance to the joiner to be aware, that, even in very old wood, when the surface is removed, the extent of variation is nearly the same as in new wood.

It appears, from Rondelet's experiments, that in wood of a mean degree of dryness, the extent of contraction and expansion, produced by the usual changes in the state of the atmosphere, was, in fir wood, from $\frac{1}{360}$ to $\frac{1}{75}$ part of its width; and, in oak, from $\frac{1}{412}$ to $\frac{1}{84}$ part of its width. Consequently, the mean extent of variation in fir is $\frac{1}{124}$, and, in oak, $\frac{1}{140}$; and, at this mean rate, in a fir board about $12\frac{1}{2}$ inches wide, the difference in width would be $\frac{1}{10}$th *of an inch.* This will show the importance of attending to the maxims of construction we have already laid before the reader; for, if a board of that width should be fixed at both edges, it must unavoidably split from one end to the other.

If a piece of wood be boiled in water for a certain time, then taken out and immediately bent into any particular form, and it be retained in that form till it be dry, a permanent change takes place in the mechanical relations of its parts; so that, though when relieved, it will spring back a little, yet it will not return to its natural form.

The same effect may be produced by steaming wood; but though both these methods have been long practised to a considerable extent in the art of ship-building, we are not aware that any general principles have been discovered, either by experiment or otherwise, that will enable us to apply it to an art like joinery, where so much precision is required. We are aware that it has been tried; but, before it can be rendered extensively useful, the relation between the curvature to which it is bent, and that which it assumes, when relieved, should be determined, and also the degree of curvature which may be given to a piece of a given thickness.

The time that a piece of wood should be boiled, or steamed, in order that it may be in the best state, for bending, should be made the subject of experiments; and this being determined, the relation between the time and the bulk of the piece should be ascertained.

For the joiner's purposes, we imagine, that the process might be greatly improved, by saturating the convex side of each piece with a strong solution of glue, immediately after bending it. By filling, in this manner, the extended pores, and allowing the glue to harden thoroughly before relieving the pieces, they would retain their shape better.

As soon as *timber* is felled, it should be laid up in some dry airy place, but out of the reach of too much wind or sun, which, when in excess, will subject it to crack and fly. It is not to be set upright, but

laid along, one tree upon another, only with some short blocks between, to give it airing room, and prevent its becoming mouldy, which will rot the surface, and produce mushrooms on it. Some persons paint the trees all over with cow-dung, which occasions their drying equally, and prevents their cracking, as they are otherwise apt to do.

Some recommend the burying of timber in the earth, as the best of all ways of seasoning it; and others have found it a fine preservative to bury their timber under their wheat in their granaries; but this cannot be made a general practice.

In Norway, they season their deal planks, by laying them in salt water for three or four days, when new sawed, and then drying them in the sun; this is found of great advantage to them; but neither this, nor any thing else, can prevent their shrinking. And it has been recommended to lay boards, planks, &c. in some pool or running stream for a few days, to extract the sap from them, and afterwards to dry them in the sun or air; by this means it is said, they will be preserved from chopping, casting, or cleaving: but against shrinking there is no remedy. Mr. Evelyn particularly recommends this method for fir.

The seasoning of timber by fire is the best way of all for piles and other pieces that are to stand under the earth, or water. The Venetians first found out this method, and the way by which they do it is this: they put the piece to be seasoned into a strong and violent flame; in this they continually turn it round by means of an engine, and take it out when it is every way covered with a thick coaly crust; by this means the internal part of the wood is so hardened, that neither earth nor water can damage it for a long time afterwards. This method is practised in many places for seasoning the posts for paling in parks, &c. and has this to recommend it, that in the very oldest ruins we have ever been acquainted with, there have been discovered many times pieces of charcoal, all of which have been found uninjured, though buried in the earth for ever so many ages. This method of charring timber is practised in many parts of England, and has been much recommended, both as to economy and effect.

For this purpose all that is necessary is to light a fire upon the ground, which shall be surrounded by a wall built with loose bricks or stones, and then, when the pieces of timber are laid across the walls, to turn them round carefully, so as to present every part to the action of the fire in succession; and when the whole surface, to the depth of three quarters of an inch, or an inch is converted to charcoal, they will be sufficiently prepared. While burning, they should have a tempo-

rary covering of boughs or other fuel to preserve them from the action of the atmosphere, which would be apt to convert part of the wood into ashes.

The most effectual mode of preserving timber from decay is to char it; but when the purpose to which it is to be applied, will not admit of that operation, the next best method is to wash it over with charcoal and water, similar to white-washing. Either of these methods will certainly preserve it from the dry rot, charcoal being the greatest anti-putrescent known, and no moisture within the influence of its action will become putrid or decomposed: and we have already shewn that this must take place before wood will perish. It may be further observed, that vegetation cannot take place where charcoal or charring is used, and the dry rot is always accompanied with that species of vegetation called fungi, and this fungus never occurs till decomposition or decay has begun. When boarded floors are to be laid upon or very near the ground, it should be strewed over with dry ashes, and the joists and under side of the boards either charred or payed over with charcoal-wash as before directed. The same should be done with the side of the wainscot next the walls. As painting is indispensable from the fashion of the times, to doors, window shutters, wainscots, &c. it would be well to have them painted once in the carpenter's shop, when the stuff is perfectly dry, and finished afterward in the building for which they are prepared. If the best seasoned stuff be put up unpainted in a new building, the quantity of moisture it will imbibe from the brick-work, plaster, &c. before it can be painted, will defeat all former care of well seasoning. As to sashes, mahogany is unquestionably the cheapest article they can be made of; for deal, when painted only a few times, will have cost more than the difference of price of that very superior wood, both as to look and durability. Air that is stagnant is equally pernicious as stagnant moisture. When it is in that state, it soon becomes decomposed, and the gas fixing upon wood, ropes, paper, and other vegetable substances, quickly brings on their destruction. Ventilation, and the use of charcoal, are the best preventives.

Glue is too important a part of the materials employed by the worker in wood, to be passed without notice.

Glue is made of the skins of all kinds of beasts; as oxen, cows, calves, sheep, &c. The older the beast is the better is the glue that is made from its hide. Indeed, it is rarely that they use whole skins for this purpose; those being applicable to better purposes: but they make use of shavings, parings, or scraps of the hides, and also horns;

and sometimes they make it of the feet, sinews, nerves, &c. of beasts; and also of the pelts obtained from furriers. That made of whole skins is the best, and that of sinews, &c. the worst: and hence, chiefly arises the difference of glues, and the advantage of English and Flemish glues.

The materials above enumerated are "first digested in lime water, to cleanse them from grease or dirt; they are then steeped in clean water with frequent stirring, and afterwards laid in a heap and the water pressed out. They are then boiled in a large brass cauldron with clean water, scumming off the dirt as it rises, and it is further cleansed by putting in, after the whole is dissolved, a little melted alum or lime finely powdered. The scumming is continued for some time, after which the mass is strained through baskets, and suffered to settle, that the remaining impurities may subside. It is then poured gradually into the kettle again, and further evaporated by boiling and scumming, till it becomes of a clear dark brownish colour. When it is thought to be strong enough, it is poured into frames or moulds about six feet long, one broad, and two deep, where it gradually hardens as it cools, and is cut out when cold by a spade in square cakes. Each of these is placed in a sort of wooden box, open in three divisions to the back; in this the glue, while yet soft, is cut into three slices, by an instrument like a bow, with a brass wire for its string. The slices are then taken out in the open air, and dried on a kind of course net-work, fastened in moveable sheds four feet square, which are placed in rows in the glue-maker's field. When perfectly hard and dry it is fit for sale. That is thought to be the best glue which swells considerably, without melting, by three or four day's immersion in cold water, and recovers its former dimensions and properties by drying. Glue, that has got frost, or that looks thick and black, should be melted over again. To know good from bad glue, the purchaser should hold it between his eye and the light, and if it appears of a strong dark colour, and free from cloudy and black spots, the article is good. When glue is used by the carpenters, they break it and soak it for about 24 hours in cold water; and then melt the soaked pieces, causing it to simmer for a quarter of an hour over a slow fire, and frequently stirring it. When cooled, it becomes a firm jelly, which may be cut by any instrument. It is merely warmed for use, and in this state spread over the surface of the wood with a stiff brush. In an interval from one to three days the pieces of wood will be so perfectly cemented, that boards thus cohering, will as readily break in any part as separate at the junction. Glued boards will not set in a freezing temperature; the stiffening

being occasioned by the evaporation of the superfluous matter of the glue, which is prevented by a considerable degree of cold.

A slight notice of the progress made in this highly useful art, both at home and abroad, may now not be out of place.

The first elementary work on that part of geometrical science, which contains the principles of joinery, appeared in France, in 1795, from the pen of the celebrated Gaspard Monge, who gave it the name of *Géométrie Descriptive*. Much of what has been given as new in English works, had been long known on the Continent; but there does not appear to have been much, if any, assistance derived from these foreign works by any writer prior to Nicholson.

The latest French work which treats of joinery is Rondelet's *L'Art de Bâtir*. It is also the best foreign work on the subject that we have seen: but it is not at all adapted to the state of joinery in England. In practice, the French joiners are very much inferior to our own. Their work is rough, slovenly, and often clumsy, and at the best is confined to external effect. The neatness, soundness, and accuracy, which is common to every part of the works of an English joiner, is scarcely to be found in any part of the works of a French one. The little correspondence, in point of excellence, between their theory and practice, leads us to think that their theoretical knowledge is confined to architects, engineers, &c. instead of being diffused among workmen, as it is in this country.

In cabinet work the French workmen are certainly superior, at least as far as regards external appearance. But when use, as well as ornament, is to be considered, our own countrymen must as certainly carry away the palm. The appearance of French furniture is much indebted to a superior method of polishing, which is now generally known in this country. For many purposes, however, copal varnish (such as coachmakers use) is preferable; it is more durable, and bears an excellent polish.

Geometry is useful in all, and absolutely necessary in some, parts of a joiner's business: but it is absurd to encounter difficulties in execution, and to sacrifice good taste, convenience, economy, and comfort, merely for the purpose of displaying a little skill in that science. It is, however, a common fault, among such architects as are better acquainted with geometrical rules than with the production of visible beauty, to form designs for no other purpose than to create difficulties in the execution.

But, when geometrical science is properly directed, it gives the mind so clear a conception of the thing to be executed, that the most intri-

cate piece of work may be conducted with all the accuracy it requires.

The practice of joinery is best learned by observing the methods of good workmen, and endeavouring to imitate them. But the sooner a workman begins to think for himself the better; he ought always to endeavour to improve on the processes of others; either so as to produce the same effect with less labour, or to produce better work.

Cabinet-making, or that part of the art of working in wood which is applied to furniture, has little affinity with joinery, though the same materials and tools be employed in both. Correctness, and strict uniformity, are not so essential in moveables as in the fixed parts of buildings; they are also more under the dominion of fashion, and therefore are not so confined by rules as the parts of buildings.

Cabinet-making offers considerable scope for taste in beautiful forms, and also in the choice and arrangement of coloured woods. It requires considerable knowledge in perspective, and also that the artist should be able to sketch with freedom and precision.

If the cabinet-maker intend to follow the higher departments of his art, it will be necessary to study the different kinds of architecture, in order to make himself acquainted with their peculiarities, so as to impress his works with the same character as the rooms they are to furnish.

There are now but few cabinet-makers, or joiners, who are disposed to have recourse to the japanner, upon every occasion in which wood is required to be coloured; on this account it may be advisable to furnish a few practical hints on this subject.

Wood may be stained yellow, by brushing it over several times with the tincture of turmeric root, made by putting an ounce of the powdered root to a pint of spirit, and after it has stood some days, straining off the tincture. A redder cast may be given to the colour by adding a little dragon's blood. A cheaper, and less bright and strong yellow may be given to wood by rubbing it over several times with the tincture of French berries, made boiling hot; and when the wood is dry, brushing it over with a weak alum-water used cold.

In order to render these stains more beautiful and durable, the wood should be brushed after it is coloured, and then varnished with the seed-lac varnish, or with three or four coats of shell-lac varnish.

For a bright red stain for wood, make a strong infusion of Brasil in stale urine, or water impregnated with pearl-ashes, in the proportion of an ounce to a gallon; to a gallon of either of which, add a pound of the Brasil wood. With this infusion, after it has stood with frequent

stirring two or three days, strained and made boiling hot, brush the wood over till it appears strongly coloured; and, while it is wet, brush it over with alum-water, made in the proportion of two ounces of alum to a quart of water.

For a less bright red, brush over the wood with a tincture, made by dissolving an ounce of dragon's blood in a pint of spirit of wine.

For a pink or rose red, add to a gallon of the above infusion of Brasil wood, two ounces of pearl-ashes, and use it as before: observing to brush the wood over often with the alum-water. These reds may be varnished as the yellows.

Wood may be stained blue by means either of copper or indigo. The brighter blue may be obtained by brushing a solution of copper, while hot, several times over the wood: and then brushing a solution of pearl-ashes in proportion of two ounces to a pint of water hot over the wood. It is stained blue with indigo, by brushing it with the indigo prepared with soap-lees, a solution of white tartar or cream of tartar, made by boiling three ounces of either in a quart of water, brushing over the wood plentifully before the tincture of indigo is quite dry. These blues may be brushed and varnished as the reds if necessary.

Wood may be stained green by dissolving verdigris in vinegar, or the crystals of verdigris in water, and with the hot solution, brushing over the wood till it be duly stained.

A light red-brown mahogany colour may be given to wood by means of a decoction of madder and fustic wood, ground in water, in the proportion of half a pound of madder and a quarter of a pound of fustic to a gallon, or instead of the fustic, an ounce of the yellow berries may be used. Brush over the wood with this solution, while boiling hot, till the due colour be obtained. The same effect may, to a considerable degree, be produced by the tincture of dragon's blood and turmeric root, in spirit of wine.

For the dark mahogany, take the infusion of madder as above, and substitute for the fustie two ounces of logwood: and when the wood has been brushed over several times, and is dry, brush it over with water in which pearl-ashes have been dissolved, in the proportion of a quarter of an ounce to a quart. The wood, in the better kind of work, should be afterwards varnished with three or four coats of seed-lac varnish; but for coarse work, with the varnish of resin and seed-lac, or they may be well rubbed over with drying oil.

Wood may be stained purple by brushing it over several times with a strong decoction of logwood and Brasil, made in the proportion of one pound of the logwood and a quarter of a pound of the Brasil, to

a gallon of water, and boiled for one hour or more. Let the wood, well coloured, dry, and be then slightly passed over by a solution of one drachm of pearl-ashes in a quart of water. A solution of gold in spirit of salt or aqua regia, will give a durable purple stain to wood.

For a deep black, the wood is brushed over four or five times with a warm decoction of logwood, made as above without the Brasil, and afterwards as often with a decoction of galls to two quarts of water, allowing it to dry thoroughly between the several applications of the liquor: thus prepared, it receives a fine deep colour, from being washed over with a solution of vitriol in the proportion of two ounces to a quart: in the room of which some use a solution of iron in vinegar, keeping the vinegar for this purpose upon a quantity of the filings of the metal, and pouring off a little as it is wanted, A pretty good black is also obtained, more expeditiously, by brushing over the wood, first with the logwood liquor, and afterwards with common ink.

A very fine black may be produced by brushing the wood over several times with a solution of copper in aqua-fortis, and afterwards with the decoction of logwood, repeated till the colour be of sufficient force, and the greenness produced by the copper overcome. The blacks may be varnished as the other colours.

Where the stains are desired to be very strong, as in the case of wood used for fineering, it is generally necessary it should be soaked and not brushed; for which purpose the wood may be cut into pieces of a proper thickness for inlaying.

The beautiful finish usually given to the best joinery and cabinet-work, depends so much on the *varnish* that is employed in its completion, that we may devote a few pages in conclusion to this interesting subject.

However apparent the different points of relation which seem to exist between the principles that constitute resins, it may readily be perceived that their identity is not completely established. They exhibit in their texture and in their physical properties, very striking differences. They cannot, therefore, all present the same phænomena, when treated separately. The necessity of the mixtures which constitute the common formulæ was soon perceived; and it is on these mixtures that the variety of the compositions, and of their results, is founded. Certain varnishes possess a drying quality in an eminent degree: these are the least durable. Others are glutinous, fat, and long in drying; but these are the strongest when they have attained to the proper degree of desiccation. Some hold an intermediate rank between these two kinds; they have therefore a mean quality between

those varnishes the most exposed to accidents, and those which present the greatest resistance to the impressions and friction of hard bodies.

A careful observation of these differences could not but induce the authors who have written on the art of varnishing, to distinguish them by the help of a classification, founded on the nature of their composition, and on the uses for which they are destined.

We have thought it our duty to follow the same order. It has the advantage of exhibiting each varnish accompanied, in some measure, by its particular properties, and of enabling artists to refer known compositions, and such as may afterwards be invented, to one of the genera or species determined by the order and nature of their component parts. This division also indicates the case in which they may be employed, and the mode of using them.

Division of Varnishes.—Two classes of varnish, divided into genera and subdivided into species, may be noticed in this work. The first class comprehends the more delicate varnishes, and such as are used for the finest work, the genera of which are borrowed from that of the substances employed, and which may belong to the vegetable kingdom, as the solution of a pure gum; or to the animal kingdom, such as isinglass (gelatin)

The second class, which is the principal object of this work, comprehends the varnishes resulting from the solution of one or more resinous substances in a spirituous or oily vehicle. It will be exceedingly convenient to divide it into several genera, each of which has its proper species. These genera and species depend on the essential quality of the varnishes; on the state of their consistence; and on the degrees of their drying quality.

The first genus comprehends the most drying varnishes that can be obtained with spirit of wine.

The second genus presents formulæ for varnish nearly similar to those of the first; but they are of a less drying nature, in consequence of the use of less drying resins. This second genus gives different species of changing varnish, which do not require so much solidity as those designed for glazing metallic surfaces.

The third genus is reserved for compositions in which the nature of the solvent is changed. Spirit of wine here gives place to essential oils, and in particular to oil of turpentine. This class ought to comprehend changing varnishes, and those distinguished by the name of *mordants.*

The fourth genus is designed for the employment of pure copal treated with oil of turpentine, and even with ether. These varnishes

vie, in point of solidity, with those of the following genus, and ought even to be preferred to them.

The fifth genus admits of fat drying oils being employed as the solvent. It contains the fat varnishes made with copal, with amber, and with caoutchouc. Their colour, which is pretty dark, confines the use of them to grounds of a dark colour.

Each composition will be accompanied with particular remarks relating to the process; to the nature and qualities of the varnish; and to the circumstances most favourable for its application. This new arrangement appears to be the more convenient, as it will better enable the artist to make use of the subjoined observations, than if they were united into one body and separated from the formulæ.

First Genus.—*Drying varnishes made with spirit of wine.—First species.* No. I.—Take spirit of wine 32 ounces; purified mastich 6 ounces; gum sandarac 3 ounces; very clear Venice turpentine 3 ounces; glass coarsely pounded 4 ounces.

Remarks.—Reduce the mastich and sandarac to fine powder; mix this powder with white glass, from which the finest parts have been separated by means of a hair sieve; put all the ingredients with the spirit into a short-necked matrass, and adapt to it a stick of white wood, round at the end, and of a length proportioned to the height of the matrass, that it may be put in motion. Place the matrass in a vessel filled with water, made at first a little warm, and which must afterwards be maintained in a state of ebullition for one or two hours. The matrass may be made fast to a ring of straw.

The first impression of the heat tends to unite the resins into a mass: this union is opposed by keeping the matters in a state of rotary motion, which is easily effected by means of the stick, without stirring the matrass. When the solution seems to be sufficiently extended, add the turpentine, which must be melted, by immersing the vessel containing it in boiling water. The matrass must be still left in the water for half an hour, at the end of which it is taken out; and the varnish is continually stirred till it is somewhat cool. Next day it is to be drawn off, and filtered through cotton. By these means it will become exceedingly limpid. This simple process is sufficient for the composition of all those species of varnishes which will form part of the first four genera, unless it is necessary to operate on a large scale. Many amateurs are satisfied with simple digestion for such varnishes, taking care to stir the mixture often. This method, which may be proper for varnish composed with spirit of wine, would be too slow for varnishes of the third and fourth genera. In general the digestion is

terminated by some hours' exposure to the sun: with the precaution of renewing the surfaces by stirring the sediment with a clean rod.

The glass directed to be used divides the parts of the mixture which has been made with the dry ingredients, and it retains the same quality when placed over the fire. It therefore obviates with success two inconveniences; in the first place, by dividing the matters, it facilitates the action of the spirit, and in the second its weight, which exceeds that of resins, prevents these resins from adhering to the bottom of the matrass, and also the discolouring of the varnish when a sand bath is employed, as is commonly the case.

It may be observed that the best spirit of wine can never become charged with more than a third of its weight of the resinous substances subjected to its action; and from a particular examination made of several kinds of varnish, the consistence of which was proper, they never indicated a greater increase of weight than a fourth part of the primitive absolute weight of the spirit employed. From this it will be seen that the best authors employ much too large a proportion in their formulæ.

When too large a quantity of matter is added to spirit of wine, the latter seizes on the most soluble parts, and has very little effect upon those which are less so. The dry parts of the resin escape the action of the liquid if only a moderate heat be employed. In this case the varnish has very little colour; but if it seems to gain in pliability, it loses in point of consistence and solidity. It is of great advantage to unite all these three characters at the same time; and this may be accomplished by limited proportions, and by employing a little more time and pains in the process.

The varnishes which constitute the first genus are employed for the most part to supply the place of glazing. They are brilliant, but do not all possess the same degree of solidity. The first species exhibit more pliability than consistence or body. The application of them seems suited to articles belonging to the toilette, such as dressing-boxes, &c. The next species possess the same brilliancy and lustre; but they have more solidity, and are exceedingly drying.

Second species of varnish of the same genus. No. II.—Take pounded copal of an amber colour, once liquefied according to the method to be hereafter described, 3 ounces; gum sandarac 6 ounces; mastich cleaned 3 ounces; clear turpentine 2½ ounces; pounded glass 4 ounces; spirit of wine 32 ounces.

Mix these ingredients, and pursue the same method as that directed for No. I

Remarks.—The opinion generally entertained of the insolubility of copal in spirit of wine, might have inspired some doubt in regard to the employment of this matter, but it may be asserted that the mixture here indicated, will give a much more durable varnish than if no copal had been employed. The great division of this substance obtained by grinding and by its mixture with other resins, favours the action of the spirit upon it; and the quantity dissolved is sufficient to give to this varnish a very remarkable degree of solidity, and which it would not have possessed in the same degree without copal.

If the practical artizan be desirous to facilitate the solution of a greater quantity of copal, he may add, to this formula 3-8ths of an ounce of camphor; but this quantity must not be exceeded.

Uses.—This varnish is designed for articles subject to friction, such as furniture, chairs, fan-sticks, mouldings, &c. and even metals, to which it may be applied with success. The sandarac gives it great durability.

First species of varnish of the same genus, intended for the same articles as No. II. No. III.—Take gum sandarac 8 ounces; pounded mastich 2 ounces; clear turpentine 4 ounces; pounded glass 4 ounces; spirit of wine 32 ounces.

Remarks.—The formula for this varnish is extracted from Watin's work. The proportion of the turpentine appears to be rather too large; because it diffuses through the varnish a viscous matter, which renders it long in drying. Besides, it communicates to it a strong smell, which to many persons is exceedingly disagreeable. This formula authorizes an observation which may be applied to many other cases: when a substance, which by its nature and consistence is exceedingly soluble, is subjected to the action of spirit of wine, it precipitates in part the other dry substances which do not possess the same degree of solubility. A kind of resinous crystallization which covers the bottom of the vessel then takes place, if the mixture be left at rest. This consideration alone would induce us to recommend only half of the turpentine directed.

Second Genus of Varnishes.—*Spirituous varnishes less drying than the former, and having a weaker smell.—First species for dressing-boxes, and other articles of the like kind &c.* No. IV. —Take gum sandarac 6 ounces; gum elemi 4 ounces; gum anima 1 ounce; camphor ½ ounce; pounded glass 4 ounces; spirit of wine 32 ounces.

Make the varnish according to the method already directed. The

soft resins must be pounded with the dry bodies. The camphor is to be added in pieces.

Remarks.—These varnishes of the second genus admit modifications in the nature of the substances which concur towards their formation. They are not so dry as those of the first genus. They give pliability, brilliancy, and solidity, to the compositions, without injuring their drying quality.

Second species of the same genus, designed for the same purposes. No. V.—Take frankincense 6 ounces; gum anima, gum elimi, of each 2 ounces; pounded glass 4 ounces; spirit of wine 32 ounces.

Make the varnish with the precautions directed for No. I.

Remarks.—Varnishes composed according to the last two formulæ, may be employed for the same purposes as those which form the first genus. They are much fitter, however, for ceilings and wainscoting, coloured or not coloured: they may even be employed as a covering to parts painted with strong water colours.

Third species of the same genus, for wainscoting, small articles of furniture, balustrades, and railing in the inside of a house. No. VI. —Take gum sandarac 6 ounces; shell lac 2 ounces; resin, white glass pounded, clear turpentine, of each 4 ounces; spirit of wine 32 ounces.

Make the varnish according to the directions given for No. I.

Remarks.—Watin prescribes eight ounces of sandarac and six ounces of turpentine. These quantities appear too large, as they are not proportioned to that of the spirit of wine.

This varnish is sufficiently durable to be applied to articles designed for daily and continual use. Varnishes composed with copal ought, however, in these cases, to be preferred. There is another composition which, without forming part of the compound varnishes, is employed with success for giving a polish and lustre to furniture made of wood: wax forms the basis of it.

Many cabinet-makers are contented with waxing common furniture, such as tables, chests of drawers, &c. This covering, by means of repeated friction, soon acquires a polish and transparency which resemble those of varnish. Waxing seems to possess qualities peculiar to itself; but, like varnish, it is attended with its inconveniences as well as advantages.

Varnish supplies better the part of glazing; it gives a lustre to the wood which it covers, and heightens the colours of that intended, in particular, for delicate articles. These real and valuable advantages are counterbalanced by its want of consistence: it yields too easily to

the shrinking or swelling of the wood, and rises in scales, or splits, on being exposed to the slightest shock. These accidents can be repaired only by new strata of varnish, which render application to the varnisher necessary, and occasion trouble and expense,

Waxing resists percussion; but it does not possess, in the same degree as varnish, the property of giving lustre to the bodies on which it is to be applied, and of heightening their tints. The lustre it communicates is dull; but this inconvenience is compensated by the facility with which any accidents that may have altered its polish can be repaired by rubbing it with a piece of fine cork. There are some circumstances, therefore, under which the application of wax ought to be preferred to that of varnish. This seems to be the case in particular with tables of walnut-tree wood in daily use, chairs, mouldings, for all small articles subject to constant employment.

But as it is of importance to make the stratum of wax as thin as possible, in order that the veins of the wood may be more apparent; this desideratum may be supplied by the following process, which was first suggested by an ingenious foreigner.

Melt, over a moderate fire, in a very clean vessel, two ounces of white or yellow wax; and, when liquefied, add four ounces of good oil of turpentine. Stir the whole until it is entirely cool, and the result will be a kind of pommade fit for waxing furniture, and which must be rubbed over them according to the usual method. The oil of turpentine is soon dissipated; but the wax, which by its mixture is reduced to a state of very great division, may be extended with more ease, and in a more uniform manner. The oil soon penetrates the pores of the wood, brings out the colour of it, causes the wax to adhere better, and the lustre which thence results is equal to that of varnish, without having any of its inconveniences.

Fourth species of the same genus. Varnish slightly coloured for violins and other stringed instruments, and even for furniture of plum-tree wood, mahogany, and rose wood. No. VII.—Take gum sandarac 4 ounces; seed lac 2 ounces; mastich, Benjamin in tears, of each 1 ounce; pounded glass 4 ounces; Venice turpentine 2 ounces; spirit of wine 32 ounces.

The gum sandarac and the lac render this varnish durable: it may be coloured with a little saffron or dragon's blood.

Fifth species of the same genus, which turners of St. Claude employ for boxes made of box-wood, of the roots of trees, &c. No. VIII.—Take seed lac 5 ounces; gum sandarac 2 ounces; gum elimi 1½

ounce; Venice turpentine 2 ounces; pounded glass 5 ounces; spirit of wine 24 ounces.

Remarks.—The artists of Paris do not all employ this formula, which required to be corrected on account of its too great dryness, which is here lessened by the turpentine and gum elimi. This composition is secured from cracking, which disfigures these boxes after they have been used for some months.

Other turners employ the gum lac united to a little emili, and turpentine digested for some months in pure alcohol exposed to the sun. If this method be followed, it will be proper to substitute for the sandarac the same quantity of gum lac reduced to powder, and not to add the turpentine to the spirit of wine, which ought to be exceedingly pure, till towards the end of the infusion.

Solar infusion requires care and attention. Vessels of a sufficient size to allow the spirituous vapours to circulate freely ought to be employed, because it is necessary that the vessel should be closely shut. Without this precaution the spirits would become weakened, and abandon the resin which they laid hold of during the first days of exposure. This perfect closing of the vessels will not admit of their being full.

In general, the varnishes applied to articles which may be put into the lathe acquire a great deal of brilliancy by polishing. A piece of woollen cloth is sufficient for the operation. If turpentine predominates too much in these compositions the polish does not retain its lustre, because the heat of the hands is capable of softening the surface of the varnish, and in this state it readily tarnishes.

Sixth species of the same genus, for giving a gold tint to articles of brass. No. IX.—Take seed lac 6 ounces; amber or copal ground fine 2 ounces; dragon's blood 40 grains; extract of red sandal wood obtained by water 30 grains; hay saffron 36 grains; pounded glass 4 ounces; spirit of wine 40 ounces.

Remarks.—To apply this varnish to articles or ornaments of brass, expose them to a gentle heat, and dip them into the varnish. Two or three coatings may be applied in this manner if necessary. The varnish is durable, and has a beautiful colour. Articles varnished in this manner may be cleaned with water or a bit of dry rag.

Seventh species of the same genus. Changing varnish, or varnish designed to change or to modify the colour of those bodies to which it is applied. No. X.—Take gamboge ¾ of an ounce; gum sandarac, gum elimi, of each 2 ounces; dragon's blood of the best

quality 1 ounce; seed lac 1 ounce; terra merita ¾ of an ounce; hay saffron 12 grains; pounded glass 3 ounces; spirit of wine 20 ounces.

Remarks.—A tincture of saffron and of terra merita is first obtained by infusing them in the spirit for twenty-four hours, or exposing them to the heat of the sun in summer. The tincture must be strained through a piece of clean linen cloth, and the residuum ought to be strongly squeezed. This tincture is poured over the dragon's blood, the gum elimi, the seed lac, and the gamboge, all pounded and mixed with the glass. The varnish is then made according to the directions already given.

It may be applied with great advantage to philosophical instruments: the use of it might be extended also to various cast or moulded articles with which furniture is ornamented.

If the dragon's blood be of the first quality, it may give too high a colour; in this case the proportion may be lessened at pleasure, as well as that of the other colouring matters.

It is with a similar kind of varnish that the artists of Geneva give a golden orange colour to the small nails employed to ornament watch-cases; but they keep the process very secret. A beautiful bright colour might be easily communicated to this mixture; but they prefer the orange colour produced by certain compositions, the preparation of which has no relation to that of varnish, and which I have successfully imitated with saline mixtures, in which orpiment is a principal ingredient. The nails are heated before they are immersed in the varnish; and they are then spread out on sheets of dry paper.

Eighth species of the same genus. Changing varnish which may be employed to give a gold colour to watch-cases, watch keys, and other articles made of brass. No. XI.—Take seed lac 6 ounces; amber, gamboge, of each 2 ounces; extract of red sandal wood in water 24 grains; dragon's blood 60 grains; hay saffron 36 grains; pounded glass 4 ounces; spirit of wine 36 ounces.

Remarks.—Grind the amber, the gum lac, gamboge, and dragon's blood together; then mix them with the pounded glass, and add the spirit, after forming with it an infusion of the saffron and an extract of the sandal wood. The varnish must then be completed as before. The metal articles intended to be covered by this varnish are heated, and those which will admit of it are immersed in packets.

The tint of the varnish may be varied by modifying the proportions of the colouring substances.

The use of spirituous varnishes will long be preferred to that of the varnishes which form the third and fourth genera; which, however,

are far superior in all cases where it is necessary to add durability to the other qualities required.

The varnishes of these first two genera bear polishing as well as the hardest compositions which constitute the three other genera: but as they are more delicate, they require modifications in the operation. It is never begun with pumice stone.

With regard to the mode of *polishing* a varnished surface, it may be advisable to state, that, where the coat of varnish is very thick, the surface may be rubbed with pumice-stone and oil, till it becomes uniformly smooth; the pumice should be first reduced to a *smooth flat* face by rubbing on a piece of freestone. The japanned or varnished surface may afterwards be rubbed with pumice reduced to an impalpable powder by pounding and washing over, using oil and a rag or leather to lay on the powder. The finishing may be given by oil and a woollen rag only.

Where the varnish is thinner, and of a more delicate nature, it may be rubbed with tripoli or rotten-stone, in fine powder, finishing with oil as before. Where the ground is white, putty or Spanish white, finely washed, may be used instead of rotten-stone, of which the colour might have some tendency to injure the ground.

Frequent references have been made, in the arts of varnishing, to the use of drying oil: it may be necessary to observe, that to render linseed oil drying, consists simply in mixing it with litharge, or any oxide of lead, boiling it slowly for some time, and straining it from the sediment, after it has stood to clarify. The oil thus treated becomes thicker as it imbibes oxygen from the oxide, and acquires the property of drying much sooner than before. An ounce of litharge may be used to every pound of oil.

THE

PAINTER'S AND PLUMBER'S

COMPLETE GUIDE.

HOUSE-PAINTING.

House Painting is an art of great antiquity, and it is more than probable, that the earliest erections of a durable nature received some additions from the pencil of the artist. Painting, as applied to buildings, comprises, in the first place, the colouring of wood, iron, &c., and to effect this, a pigment is spread over them with a brush, so that by a repetition of several coats, the material is preserved and its appearance improved.

The object of this division of our work is to give an account of some mechanical proceedings in certain kinds of painting, calculated to preserve and embellish the walls of houses and furniture. This branch of the art extends to every part of architecture. The whole building becomes the workshop of the artist; the stairs, the ballustrades, the sashes, the doors, and the railing of all kinds, occupying his first care, and then the cielings and wainscotting.

The artist gives to all his subjects a chosen and uniform tint; but he has it in his power to vary the colours on different parts of the building in such a manner as to produce the most pleasing effect.

Among the utensils of the painter, it is needless, but for rendering the article complete, to mention brushes and pencils of all sizes as absolutely necessary.

The brushes are made of boars' bristles, or of hair with a mixture of bristles; they ought to be straight, very smooth, and of a round form. Half an hour before they are used, it is proper to soak them in water, in

order to swell the wood of the handle, and prevent the hairs from falling off; after this they may be applied to all purposes, either in water colours or in oil: but it may be observed, that for the former they require less softening.

The pencils are made of badgers' hair, or any fine hairs encased in the pipes of quills of all sizes.

The vessel wherein the pencils are cleaned is made of copper or of tin, smooth below, rounded at the ends, and divided into two parts by a thin plate in the middle. The oil, or the substance with which the pencil is cleaned, is contained in one of the divisions.

The pallet is made of the wood of the pear or apple tree, of an oval or square shape, very slender, but somewhat thicker at the centre than at the extremities. A hole is made in one of its sides sufficiently large to admit the thumb of the workman.

When the pallet is new, it is covered with oil of walnuts; and as often as it dries, the operation is repeated, till it be fully impregnated; it is afterwards polished, and finally rubbed with a piece of linen dipped in oil of common nuts.

The painter's knife is a thin flexible plate, equally slender on both sides, rounded at one extremity, and the other fixed into a handle of wood.

All the vessels employed to hold the colours should be varnished; a precaution necessary to prevent their drying too quickly; and they may be cleaned with a piece of marble or any hard stone, by means of water, oil, or essence.

To grind, is to reduce to powder the substances which give colours; and to dilute, is to impregnate a liquid with a tint in such a manner as to make it capable of being applied by a brush.

When the materials are ground in water, it is proper *to dilute* them in size made from parchment. If they are diluted by spirit of wine, there must be no more diluted than what serves the immediate occasion, as colours prepared in this manner dry very rapidly.

Colours ground in oil, are sometimes diluted with pure oil, more frequently with oil mixed with essence, and commonly with the simple oil of turpentine; the essence makes the colours easy to work.*

* Oil of turpentine, or, as it is called, *turps*, is in general use in house-painting, and is the ingredient by which the flatting, as it is termed, is performed. All the larch and fir-trees furnish a resin, known by the general name of turpentine. Commerce distinguishes several qualities according to its degree of goodness. The larch-tree furnishes what is called Venice turpentine; it is obtained by being made to flow from the trunk of the tree through holes made

When colours are ground with the oil of turpentine, and diluted in varnish, as they require to be immediately applied, it is necessary to prepare a small quantity at a time. This preparation of colours gives greater brilliancy, and dries more speedily, than those prepared in oil; but they require more art to manage them.

They grind colours or coloured substances with a mullet, which is employed on the stone till they become a very fine powder. The operation is facilitated by moistening them from time to time with a little water, and by collecting them under the mullet with the knife. They are afterwards laid in small heaps on a sheet of white paper, and allowed to dry in a situation not exposed to dust. Those who grind white lead have a stone for the purpose, as this colour is very easily tarnished. In executing this part well, it is necessary to grind the colours equally and moderately; to grind them separately, and not to produce a tint by mixture till the colours are well prepared.

Dilute no more at a time than what you have occasion to employ, to prevent them from growing thick.

In grinding the colours, put in no more liquid than what is necessary to make the solid substances yield easily to the mullet: the more the colours are ground, they better they mix, and give a smoother and more agreeable painting.

It is also necessary to give all attention to the grinding and diluting of colours, that they may be neither too thick nor too thin.

Prepare only the quantity necessary for the work you undertake, because they do not keep long; and those which are newly mixed are more vivid and beautiful. Hold the brush straight before you, and allow only the surface to be applied to the subject; if you hold it inclined in any other direction, you will run the hazard of painting un-

with an auger, in which small pipes are fixed, that conduct the juice into buckets placed to receive it. This turpentine has a yellowish and limpid colour, a strong aromatic smell, and bitter taste. In Canada, the peasants collect it from the fir-tree by perforating the sacs, which contain it under the bark, with the point of a horn which is filled with this juice. It is afterwards distilled, on which it liberates an oil more or less volatile, according to the degree of heat employed. When the operation is done by a bath, a white, limpid, and odoriferous oil is obtained, which is called essence of turpentine. The residue from this distillation forms the boiled turpentine of commerce. This is sold at the colour shops in the same way in which oil is, viz. by the gallon. This, as well as the oil, considerably improves by age: hence all painters in a large way of business keep it by them in quantities, which enables them to depend on their work retaining its colour: a circumstance of no little importance in our present mode of house-painting.

equally. It is necessary to lay on the colours boldly and with firm strokes; taking care at the same time to spread them equally over the surface, and not filling up the moulding and carved work. If this accident should happen, you must have a little brush to clean out the colours. Stir them frequently in the vessel, that they may preserve always the same tint, and that no sediment may remain at the bottom. Take care not to overcharge the brush with the colour. Never apply a second layer till the first or preceding one be perfectly dry; which it is easily known to be when, in bearing the hand gently over it, it does not adhere. In order to render this drying more speedy and uniform, make always the layers as thin as possible. Before painting, it is necessary to prime the subject; that is, to give it a layer of size, or of white colouring oil, to fill up the pores, and render the surface smooth: by this means fewer layers of colour or of varnish are afterwards necessary. Every subject to be painted or gilt with leaf gold ought to have first a white ground; this preserves the colours fresh and vivid, and repairs the damage which they occasionally receive from the air.

To paint in water-colours, which from its simplicity should first occupy the artist's attention, is to do it in those which are ground in water and diluted in size. There are three kinds of this painting; namely, *common*, the *varnished*, and that which is called *king's white*; but before entering on these, it is necessary to make some preliminary observations.

1. Take care that there be no grease on the subject; and if there be, scrape it off, or clean it with a lye, or rub the greasy part with garlic and wormwood.

2. Let the diluted colour fall in threads from the end of the brush when you take it out of the vessel; if it adheres to it, it is a proof that it wants size.

3. Let all the layers, especially at the beginning, be laid on very warm, provided that the liquid be not boiling, which would effectually spoil the subject; and if on wood, expose it to crack. The last layer, given immediately before the varnish, is the only one which ought to be applied cold.

4. In very fine work, where it is necessary to have beautiful and solid colours, the subjects are prepared by size and proper whites, which serve as a ground to receive the colour, and render the surface very equal and smooth.

5. Whatever colour is to be laid on, the white ground is the best, as it assimilates most easily with the painting, which always borrows something of the ground.

To make the following details sufficiently plain, we shall take the measures to which the quantity of colours are applied at fathoms; that is to say, six feet in height by six feet in breadth. We shall afterwards fix the quantity of materials, and of liquids necessary to cover this surface. This, however, cannot be exactly defined; as some subjects imbibe the colours much more than others. The manner of employing them also makes a difference; as habit enables one to manage them to greater advantage than another. And it is also to be observed, that the first layer will consume more than the second; and that a prepared subject requires less than one which has not been so.

When we speak of a fathom, it must be understood of a smooth and equal surface; for if the wood is varied with mouldings and carving, there must be a difference in the quantity of colours. In general it requires about a pound of colours to paint a square fathom in water-colours. In making up this quantity, take three-fourths of colours ground in water, and to this add about six ounces of size, to dilute it.

Works which require no great care or preparation, as cielings and stair-cases, are generally painted in common water colours, *i. e.* with earths infused in water and diluted in size.

For a common white kind of this painting, steep Spanish white moderately pounded in water for two hours. Infuse a proper quantity of the black of charcoal in water for the same space of time; mix the black and white in the proportion that the tint requires; afterwards mix them up with a pretty strong size, sufficiently thick and warm, and apply them to the subject in as many layers as may be thought necessary. It requires about two pounds of white in a pint of water, and a quantity of black in proportion to the tint, together with a part of size, to cover a square fathom. If this be employed on old walls, they must be well scraped, the dust brushed off with a hair broom, and washed carefully with lime water. If on new plaster, the colours require more size.

All kinds of colours may be ground in water only when the tint is made; and when they have been infused in water, they must be mixed up with size.

The white *des carmes* is a manner of whitening interior walls, whereby they are rendered extremely beautiful. To effect this procure a quantity of the very best lime, and pass it through fine linen; pour it into a large tub, furnished with a spigot at the height equal to that which the lime occupies: fill the tub with clear spring

water; beat the mixture with instruments of wood, and then allow it to settle for 24 hours.

Open the spigot, allow the water to run off, supply the tub with fresh water, and continue this operation for several days until the lime receives the greatest degree of whiteness.

When you allow the water finally to run off, the lime will be found in the consistency of paste; but with the quantity you use it is necessary to mix a little Prussian blue or indigo to relieve the brightness of the white, and a small quantity of turpentine to give it brilliancy. The size proper for it is made of glove-leather, with the addition of some alum; and the whole is applied with a strong brush in five or six layers to new plaster.

The wall is rubbed over strongly with a brush of hogs bristles after the painting is dry; which gives it its lustre and value, and which makes it appear like marble or stucco.

Badegeon is a pale yellow colour applied to plaster to make it appear like free stones. It gives to old houses and churches the exterior of a new building, by assuming the colour of stones newly cut. Take a quantity of lime newly slaked. Add to it the half quantity of what the French call *sciure de pierre,* in which you have mixed of the ochre of *rue,* according to the colour of the stone you intend to imitate. Steep the whole in a pail of water, in which is melted a pound of rock alum. When the *sciure de pierre* cannot be obtained, it is necessary to use a greater quantity of ochre *de rue,* or of yellow ochre, or grind the scales of the stone de St Leu; pass it through a sieve; and along with the lime it will form a cement, on which the weather will scarcely make any impression.

When the ceilings or roofs are new, and you wish to whiten them, take white of Bougival, to which add a little of the black of charcoal to prevent the white from growing reddish: infuse them separately in water; mix the whole with half water and half size of glove-leather, which being strong would make the layer come off in rolls if it were not reduced with water. Give two layers of this tint while it is lukewarm.

If the roof has been formerly whitened, it is necessary to scrape to the quick all the remaining white; then give it two or three layers of lime to ground and whiten it. Brush it carefully over; and give it two or three layers of the white of Bougival prepared as before. Clean them with a very strong brush, and carefully rub off the dust and rust; pound about a quarter of a pound of lead ore into a fine powder, and put it into a vessel with half a pint of vinegar; then apply

it to the back of the chimney with a brush: When it is made black with this liquid, take a dry brush, dip it in the same powder without vinegar, and dry and rub it with this brush till it become shining as glass.

The advantages of this kind of painting are, that the colours do not fade; that they reflect the light; that they give no offensive smell, but permit the places to be inhabited as soon as finished; and that the varnish preserves the wood from insects and moisture.

To make a fine varnish on water-colours, seven principal operations are necessary; namely, to size the wood, to prepare the white, to soften and rub the subject, to clean the moulding, to paint, to size, and to varnish.

To size the wood is to give one or two layers of size to the subject which you intend to paint. To make which in the most perfect manner, take three heads of garlic and a handful of wormwood leaves; boil them in three pints of water till they are reduced to one; pass the juice through a linen cloth, and mix it with a pint of parchment size; add half a handful of salt and half a pint of vinegar; and boil the whole on the fire.

Size the wood with this boiling liquor; allow it to penetrate into the carved and smooth places of the wood, but take care at the same time to take it as clean off the work as possible, or at least to leave it at no one place thicker than another. This first sizing serves to fill up the pores of the wood, and to prevent the materials afterwards from collecting in a body, which would cause the work to fall off in scales.

In a pint of strong parchment size, to which you have added four pints of warm water, put two handfuls of white Bougival, and allow it to infuse for the space of half an hour.

Stir it well, and give a single layer of it to the subject very warm but not boiling, equally and regularly laid on, and dashed with repeated strokes of the brush into the mouldings and carved work.

To prepare the white, take a quantity of strong parchment size, and sprinkle lightly over it, with the hand, Bougival white, till the size be covered with it about half an inch in thickness; allow it to soak for half an hour as near the fire as to keep it milk warm; and then stir it with the brush till the lumps are broken, and it be sufficiently mixed.

Give seven, eight, or ten layers of this white, or as many as the nature of the work or the defects in the wood shall render necessary, giving more white to the parts which require to be softened; but in general, the layers must be equal both with regard to the quantity of the white and the strength of the size.

The last layer of the white ought to be clearer than the rest, which

is made by adding water. It must be applied more slightly, taking care with small brushes to cover all the difficult places in the mouldings and carved work. It is necessary also, between the drying of the different layers, to fill up all the defects with white mastich and size.

The wood being dry, take little pieces of white wood and of pumice-stone, ground for the purpose into all necessary forms, either for the panels or the mouldings. Take cold water, heat being destructive of this kind of work: in summer it is common to add a little ice. Soften the wall with a brush, but only as much at a time as you can easily work, as the water might dilute the white and spoil the whole: then smooth and rub it with the pumice-stones and with the small pieces of wood: wash it with a brush as you smooth it, and rub it over with a piece of new linen, which gives a fine lustre to the work.

The mouldings and carved work are cleaned with an iron knife; and the only thing to be attended to in the operation is not to raise the grain of the wood.

The subject thus prepared is ready to receive the colour you intend to give it. Choose your tint; suppose a silver colour.

Grind white ceruse and Bougival white separately in water, of each an equal quantity, and mix them together.—Add a little blue of indigo and a very small quantity of black of charcoal from the vine-tree very fine, ground also separately, and in water; more or less of the one or other gives the tint you require.—Dilute this tint in strong parchment size; pass it through a bolting cloth of silk very fine, and lay the tint on your work, taking care to spread it very equally; and then give it two layers, and the colour is applied.

Make a weak, beautiful, and clean size; stir it till it cools; strain it through a fine cloth, and give two layers to the work with a soft painting brush, which has been used, but which you have been careful to clean. Take care not to choak up the mouldings, nor to lay on the size thicker on one place than another, and spread it over the work very slightly, otherwise the colours will be injured, and undululations in the painting will be the result.

The beauty of the work depends on this last sizing; for if any part is omitted, the varnish will penetrate into the colours and give it a darker shade.

When the sizing is dry, lay on two or three layers of spirit of wine varnish, taking care that the place on which you lay it be warm, and the work is finished.

King's White derives its name from the use of it in the apartments of the French king. It is in all respects conducted like the former, ex-

cept that there is only a small quantity of indigo, to take the yellow from the white, without any black of charcoal, and without varnish.

This white answers extremely well for apartments which are seldom used; but otherwise it spoils easily, especially in bed-chambers. It is the best white where there is any kind of gilding: and in this case it may receive a little varnish.

The disagreeable smell perceived on entering rooms newly painted in distemper is universally known. It is only after having left these rooms exposed to the action of the air, that they are habitable. A process which remedies these two inconveniences, deserves therefore to be adopted, and it is with that view that it has been published by M. Carbonell, a Spanish physician.

The mode of operation described by the author is very simple, it consists in substituting the serum of the blood of animals, instead of the solution of glue or size, commonly used to mix up the colouring matter.

To succeed, the following methods must be used:

1st. The butcher must be directed to receive the blood of one or more oxen in proper vessels. When the blood is quite cold, that is to say, three or four hours after it is drawn, the vessels must be gently inclined, by which means, a clear amber-coloured liquor will be decanted. This must be passed through a strainer to separate the impure fragments which have broken off and been mixed with it.

2d. Reduce to powder quick lime, which has been sprinkled with a little water to diminish the adhesion of its integrant parts. Pass this powder through a sieve, and deposit it immediately in boxes or bottles well closed.

3d. When these two materials are to be used, the serum is first poured into a wooden or earthen vessel, and mixed with a sufficient quantity of lime, pulverized as directed above, taking care to preserve the mixture of a proper fluidity to be easily spread with the brush over the surfaces to be covered.

4th. Too great a quantity of this paint must not be prepared at once; because it thickens very fast, and when it has acquired too much consistence it cannot be used. This inconvenience may, however, be remedied by keeping the fluidity at the same point, by the addition of a sufficient quantity of serum, which should always be kept in a vessel near that containing the paint, that it may be used when necessary

5th. The colour so prepared, should be used as quickly as possible.

6th. As the colour resulting from the application of this preparation 's always white, and as there are circumstances in which a different

colour is wished for, this may be obtained, by adding a bolar earth of a red, black, green, or yellow species to the serum, at the same time as the lime is mixed. Even a beautiful blue may be obtained by using the blue glass prepared from oxide of cobalt, provided it be reduced to an impalpable powder.

7th. The strength of the composition being necessarily lessened by the addition of the bolar colouring matters, the same degree of solidity may be preserved by adding to the serum used for diluting this composition, a few whites of eggs; but particular care must be taken not to put too many, otherwise the paint will be subject to scale off.

8th. This paint can only be applied on wood work or coatings of plaster, which have not been previously covered with oil-paint.

9th. As one layer will not be sufficient, two or three may be laid on those surfaces which are required to be well painted; but before laying on a second coat, that which has been already applied must be perfectly dry.

10th. A beautiful polish may be given to the paint by friction, in the same manner as to other sorts of paint; it need only be observed, that it is better to grease the cloths used for rubbing it, with clear whale oil, rather than with any other material.

11th. To temper this paint, whether white or coloured, it is necessary that the serum should be fresh and not have undergone any change, otherwise the paint will be of a bad quality and not durable.

The preservation of the serum, particularly in the summer, requires much caution, because this fluid has a great tendency to putrefy. It is, therefore, essential to keep it in a cool place, and to examine before using it, whether it has began to emit a bad smell; for, in that case, care must be taken not to use it. For the same reason the vessels in which the serum is kept must be carefully cleaned, and washed frequently with hot water; to remove the spoilt portions of this fluid, with which the pores of the vessels might be impregnated.

M. Carbonell asserts, that this paint is so durable, that, when prepared with good materials, it may be used to paint the walls of damp houses, without fear of its coming off; an advantage certainly not possessed by distemper painting.

The same author also asserts that he has made many experiments with this same paint, and has obtained satisfactory results; and in all cases so constant, that he doubts not, when it shall be known, that it will be generally adopted. He instances, among other examples, the use which is made of it at Barcelona, as well the exterior of buildings as within side, and he always observed, not only that the sun, the

air, moisture, or draught, produce no change on it, but also that it is free from any bad smell; so much so, that places where it has been used may be inhabited without danger the very day of its application.

We might be disposed, at the first glance, to believe that the new paint proposed by M. Carbonell, is nearly the same with that of milk, described some years ago by Cadet Devaux. This latter paint may have also succeeded; but on reflecting on the essential difference which exists between the serum of the blood and that of milk, it will soon be perceived that if the milk paint is good, that of M. Carbonell must be better. But experience must decide in this respect, and it is to be presumed that a short time will make known which of the two methods deserves the preference.

The work in which M. Carbonell has given the details relative to the preparation and use of his paint with serum, is dedicated to the queen of Spain. This work has been printed in the Spanish language: and it might advantageously find a place in the works of science which proceed from the press of this country.

We may now direct the reader's attention to the subject of painting in oil.

By means of oil the colours are longer preserved; and not drying so speedily, they give painters more time to smooth, finish, and retouch their works; the colours being more marked, and mixing better together, give more distinguishable tints, and more vivid and agreeable gradations, and the colouring is more delicate.

The painting in oil consists of two kinds, namely, of that in simple oil, and of that in polished oil varnish. The following may be considered as important introductory details.

1. When bright colours, as white or grey, are ground and diluted in oil, it is advisable to make use of the oil of walnuts; but if the colours be dark, such as chesnut, or olive, or brown, you must make use of pure linseed oil.

2. When the colours are ground and diluted in oil, they must be laid on cold, except on a new or moist plaster, which requires them to be heated.

3. Every colour diluted in pure oil, or in oil mixed with essence, ought to fall in threads from the end of the brush.

4. Take care to stir from time to time your colour before taking it up on the brush, that it may preserve an equal thickness, and consequently the same tone. Notwithstanding the precaution of stirring, if it is found to be thicker towards the bottom, it will be necessary to

pour in from time to time a little oil, and thus preserve it of the same consistence.

5. In general, every subject which is painted in oil ought first to receive one or two layers of white ceruse, ground and diluted in oil.

6. When the painting is exposed to the air, as in doors, windows, and other works, which cannot be varnished, it is advisable to make these layers with pure oil of walnuts, mixed up with about one ounce of essence to a pound of colours; more would make the colours brown, and occasion them to fall off in dust; but this quantity prevents the sun from blistering the work.

7. In subjects on the inside of the house, or when the painting is varnished, the first layer ought to be ground and diluted in oil, and the last diluted with pure essence.

8. If copper or iron, or other hard substances, are to be painted, it is necessary to mix a little essence with the first layers, to make the oil penetrate into them.

9. When there are many knots in the subject, as is particularly the case with fir-wood, and when the colour does not easily take impression on these parts, it is necessary, when you paint with simple oil, to lay on a little oil mixed with litharge on the knots. If you paint with polished oil varnish, it is necessary to apply a hard tint, which we shall have occasion to speak of afterwards. A single layer well applied is generally sufficient to give a body to the wood, and make the other layers apply easily.

10. There are colours, such as what the French call *stils-de-grain*, black of charcoal, and especially bone and ivory-blacks, which are difficult to dry when ground in oil. To remedy this inconvenience the following siccatives are mixed with the colours, to make them dry, viz. litharge both of the silver and gold colour, vitriol or copperas, and what is called *siccative oil.*

It may be recommended not to mix the siccatives with the colours till they are to be employed, otherwise it will thicken them: but mix it only in very small quantities in preparations of tin, wherein there is white lead or ceruse, because those colours are drying of themselves, especially when they are diluted in spirits of turpentine.

In painting which is to be varnished, give the siccative only to the first layer, and allow the other layers, in which there is spirit to dry of themselves.

In dark colours in oil, give to every pound of colours in diluting them half an ounce of litharge; to bright colours a drachm of white copperas ground in walnut oil

When in place of litharge or copperas the siccative oil is employed, it requires a quarter of a pint of this oil to every pound of colour.

The siccative oil is prepared of one half ounce of litharge, as much of calcined ceruse, as much of *terre d'ombre*, a colour with which the French paint shadows, and as much of talc boiled for two hours on a slow and equal fire, with one pound of linseed oil, and stirred the whole time. It must be carefully skimmed and clarified, and the older it grows the better it is.

Ochres and earths require more liquids both in grinding and diluting than ceruse. Different quantities of liquids are required in the grinding only on account of greater or less dryness; but in diluting, the quantity is always the same.

For the first layer after the priming, which has no relation to the colours laid on afterwards, to a square fathom give fourteen ounces of ceruse, about two ounces of liquid to grind, and four ounces to dilute it. If there is a second layer of the same materials, the quantities will require to be less.

It will require three pounds of colour for three layers of a square fathom. The first may consume eighteen ounces, the second sixteen, and the third fourteen.

To compose these three pounds of colour, take two or two and a half pounds of ground colours, and dilute them in a pint or three half pints of oil, mixed with essence or pure oil. But if the first layer of ceruse is not used, there will be a necessity for a greater quantity of colours.

For painting in simple oil, on doors and windows give a layer of ceruse ground in common oil diluted with the same fluid, together with a little siccative; then give another layer of the same preparation; to which, if you want a greyish colour, add a little black of charcoal and Prussian blue, ground also in oil of walnuts. If to these the painter be inclined to add a third layer, grind and dilute it in pure oil; observing that the two last layers be less clear, or have less oil in them, than the first; the colour in this case is more beautiful and less apt to blister with the sun.

Walls that are to be painted must be very dry; and this being supposed, give two or three layers of boiling linseed oil to harden the plaster; then lay on two layers of ceruse or ochre, ground and diluted in linseed oil; and when these are dry, paint the wall.

To paint tiles of a slate colour, grind separately ceruse and German black in linseed oil; mix them together in the proportion which the colour requires, and dilute them in linseed oil: then give the first layer

very clean to prime the tiles; and make the three next layers thicker, to give solidity to the work.

To paint arbours and all kinds of garden work, give a layer of white ceruse ground in common oil, and diluted in the same oil, with the addition of a little litharge; then give two layers of green, composed of one pound of verdigrise and two pounds of white lead, ground and diluted in the same manner as the first portion. This green is of great service in the country for doors, window shutters, arbours, garden-seats, rails, either of wood or iron; and in short for all works exposed to the injuries of the weather.

To whiten statues, vases, and all ornaments of stone, either within or without doors; first clean the subject well, then give one or two layers of white ceruse, ground and diluted in pure or refined oil, and finish with giving one or more layers of white lead prepared in the same manner.

If you wish to paint on walls not exposed to the air, or on new plaster, give one or two layers of boiling linseed oil, and continue the brush till the walls are fully soaked; then give a layer of white ceruse, ground in common oil and diluted with three fourths of the same oil and one fourth spirits; and lastly, give two layers more of white ceruse, ground in oil of walnuts and diluted in oil mixed with essence, if it is not to be varnished; but in pure essence if it is. It is in this manner that walls are painted white. If you adopt another colour, it is necessary to grind and dilute it in the same quantities of oil and essence.

To paint chairs, benches, stone, or plaster, in a superior way, give a layer of white ceruse ground in oil of walnuts and diluted in the same oil, into which you have cast a little litharge to make it dry; then apply a layer of the tint you fix on, ground in oil and diluted in one part oil and three parts essence; and afterwards give two more layers of the same tint ground in oil and diluted in pure essence: this may be varnished with two layers of spirit of wine.

To make a steel colour, grind separately in turps, white ceruse, Prussian blue, fine lac, and verdigrise. The tone which you require is procured by the proper mixture of those ingredients. When you have fixed on the tone of colour, take about the size of a walnut of the ingredients, and dilute them in a small vessel in one part of turps and three parts of white oily varnish. *N. B.* This colour is generally made of white ceruse, of black charcoal, and Prussian blue, ground in thick oil, and diluted in essence, which is the cheapest method of procuring it; but the former is the most beautiful.

For painting ballustrades and railings, dilute lamp-black with

varnish of vermilion; giving two layers of it, and afterwards two layers of spirit-of-wine varnish.

Since the discovery of oil-painting, and the knowledge that wood is preserved by it, and especially since the discovery of a varnish without smell, and which even takes away that of oil, the painting of apartments in oil has been with justice preferred.

In fact the oil stops up the pores of the wood; and although it does not altogether resist the impression of moisture, yet the effect is so little perceptible, that it is to be recommended as the best method of preserving wood.

To preserve wainscoting in the most effectual manner from moisture, it is necessary to paint the wall behind it with two or three layers of common red, ground and diluted in linseed oil.

To paint the wainscoting itself, give a layer of white ceruse ground in nut oil, and diluted in the same oil mixed with essence. This layer being dry, give two more of the colour you have adopted, ground in oil and diluted in pure essence. If you wish the mouldings and sculpture to be painted in a different colour, grind and dilute it in the same manner.

Two or three days after, when the colours are fully dry, give two or three layers of white varnish without smell, and which also prevents the offensive smell of the oil colours; and it may be proper to remark that those who begin their operations in water colours, if they find it more agreeable, may finish it in oil colours as above.

When the pores of the wood are well stopped by the prepared white, a layer of white ceruse ground in nut oil, and diluted in the same oil, mixed with essence, may be applied. This will be sufficient, the wood being previously primed; and afterwards lay on your intended colour and varnish.

Painting in oil with the polished varnish is the best kind of oil-painting, owing more to the care it requires than to the proceedings, for they are nearly the same with those of simple oil-painting; the difference consisting only in the preparation and manner of finishing.

To paint wainscotings of apartments with the polished varnish, it is necessary, in the first place, that the panels be new. Then, the following instructions may be attended to.

1. Make the surface of the subject which you mean to paint very smooth and level, which is done by a layer of colour, which serves to receive the hard tint or polished ground and the colours.

This layer ought to be of white, whatever colour you are afterwards

to apply. It consists of white ceruse, ground very fine in linseed oil, with a little litharge, and diluted in the same oil mixed with essence.

2. Make the polished ground by seven or eight layers of the hard tint. In painting carriage equipages, a dozen is necessary. The hard tint is made, by grinding pure white ceruse, which has not been much calcined, very finely in thick oil, and diluting it with turps; but the painter must take care that the layers of the hard tint be not only equal as to the application, but to the quantity of the white ceruse and the oil, and to the degree of calcination. Then,

3. Soften this ground with pumice-stone.

4. Polish it moderately with a piece of serge soaked in a pail of water, in which you have put some powder of pumice-stone finely ground and passed through a fine sieve. There is no occasion to spare washing, as this part of the operation will not spoil with water.

5. Choose the tint with which you intend to decorate your apartment; grind it in oil, and dilute it in essence; pass it through a piece of very fine silk, give two or three layers carefully and thinly spread over the surface, as on this part of the operation depends in a great measure the beauty of the colour. All sorts of colours may be employed in this manner in oil of turpentine.

6. Give two or three layers of a spirit-of-wine varnish, if it is to wainscoting; if to the body of a coach, a varnish of oil is employed. If the varnish is to be polished, it is necessary to give seven or eight layers at least, laid on equally and with great precaution, not to be thicker in one place than another, which occasions spots.

7. It is again polished with pumice-stone reduced to powder, and water and a piece of serge. If the wainscoting has been painted before, it is necessary to rub off the colour till you come to the hard tint, which is done with pumice-stone and water, or with a piece of linen dipped in turps.

There is a white painting in oil, called *white varnish polish*, which corresponds to the king's white in water colours, and is equal to the freshness and gloss of marble if it is applied to wood. To paint in this manner,

Give a layer of white ceruse ground in oil of walnuts, with a little calcined copperas, and diluted in essence. But if it is applied to stone, it is necessary to employ oil of walnuts and calcined copperas alone.

Grind white ceruse very fine in essence of turps, and dilute it in fine white oil varnish with copal. Give seven or eight layers of it to the

subject. The varnish mixed with the white ceruse dries so promptly, that three layers of it may be given in a day. Soften and polish all the layers as above. Give two or three layers of white lead ground in oil of walnuts, and diluted in pure essence.

Give seven or eight layers of white spirit-of-wine varnish, and then polish them.

To paint in varnish, is to employ colours ground and diluted in varnish; either in spirits of wine or oil, on all sorts of subjects. Wainscoting, furniture, and equipages, are painted in this manner, though we shall confine ourselves to the first.

1. Give two layers of white of Bougival, diluted in a strong size boiling hot. 2. Give a layer of what the French call *de blanc apprit.* 3. Fill up the defects of the wood with mastich in water; and when the layers are dry, smooth them with the pumice-stone.

4. When the wood is smooth, suppose the paint a grey colour, take one pound of white ceruse, one drachm of Prussian blue, or of black of charcoal or ivory black; put the white into a piece of leather, so tied that the colours cannot escape; shake them till they are sufficiently mixed. 5. Put two ounces of colours into a quartern of varnish, mix them carefully; give one layer above the white. 6. This layer being dry, put one ounce of colours into the same quantity of varnish as above, and give a second layer.

7. To the third layer give half an ounce of colour to the same quantity of varnish.

8. As each of these layers dry, be careful to rub them with a piece of new coarse cloth, in such a manner, however, as not to injure the colour. The three layers may be given in one day.

9. If you want to give a perfect lustre, add a fourth layer prepared as the third.

All other colours, as blue, &c. may be applied in the same manner. This method is the only one by which orpiment can be employed in all its beauty, but not without some of its inconveniences.

Another manner of performing this kind of work, is to apply the colours and the varnish without previously using the size and the white ground. This is extremely expeditious, but it is easy to perceive it will want the polish and brilliancy of the other.

We cannot perhaps more properly conclude this part of our subject, than with an account of M. de Morveau's attempts to render more perfect the proportion of colours, and especially of *white*, employed in painting. These we shall extract from a memoir of his, read in the academy of Dijon.

"White (says the ingenious academician) is the most important of all colours in painting. It affords to the painter the materials of light, which he distributes in such a manner as to bring his objects together, to give them relief, and that magic which is the glory of his art. For these reasons I shall confine my attention at present to this colour.

"The first white which was discovered, and indeed the only one yet known, is extracted from the calx of lead. The danger of the process, and the dreadful distemper with which those employed in it are often seized, have not yet led to the discovery of any other white. Less anxious, indeed, about the danger of the artist than the perfection of the art, they have varied the preparation, to render the colour less liable to change. Hence the different kinds of white, viz. white of *crems* in Austria, white lead in shells, and white ceruse. But every person conversant in colours, knows that the foundation of all these is the calx of lead, more or less pure, or more or less loaded with gas. That they all participate of this metallic substance, will indeed appear evident from the following experiment, which determines and demonstrates the alterability of colours by the phlogistic vapour.

"I poured into a large glass bottle a quantity of liver of sulphur, on a basis of alkali, fixed or volatile, it makes no difference; I added some drops of distilled vinegar, and I covered the mouth of the bottle with a piece of pasteboard cut to its size, on which I disposed different samples of crems, of white lead, and of ceruse, either in oil or in water; I placed another ring of pasteboard over the first, and tied above all a piece of bladder round the neck of the bottle with a strong packthread. It is evident, that in this operation I took advantage of the means which chemistry offers to produce a great quantity of phlogistic vapour, to accomplish instantaneously the effect of many years; and, in a word, to apply to the colours the very same vapours to which the picture is necessarily exposed, only more accumulated and more concentrated. I say the same vapour, for it is now fully established, that the smoke of candles, animal exhalations of all kinds, alkalescent odours, the electric effluvia, and even light, furnish continually a quantity more or less of matter, not only analogous, but identically the same with the vapour of vitriolic acid mixed with suphur.

"If it happens that the samples of colours are sensibly altered by the phlogistic vapour, then we may conclude with certainty, that the materials of which the colours are composed, bear a great affinity to that vapour; and since it is not possible to preserve them entirely from it in any situation, that they will be more or less affected with it, according to the time and a variety of circumstances.

"After some minutes continuance in this vapour, I examined the samples of colours submitted to its influence, and found them wholly altered. The ceruse and the white lead both in water and oil were changed into black, and the white of crems into a brownish black; and hence those colours are bad, and ought to be abandoned. They may indeed be defended in some measure by varnish; but this only retards for a time the contact of the phlogistic vapour; for as the varnish loses its humidity, it opens an infinite number of passages to this subtile fluid.

"After having ascertained the instability of the whites in common use, I made several attempts to discover such as would prove more lasting; and though many of these attempts were without effect, I shall give a succinct account of the whole, which may save a great deal of trouble to those who wish to travel over the same field.

"There are three conditions essential to a good colour in painting.

"*First*, That it dilute easily, and take a body both with oils and with mucilages, or at least with the one or other of these substances, a circumstance which depends on a certain degree of affinity. Where this affinity is too strong, a dissolution ensues; the colour is extinguished in the new composition, and the mass becomes more or less transparent; or else the sudden re-action absorbs the fluid, and leaves only a dry substance, which can never again be softened. But if the affinity is too weak, the particles of colour are scarcely suspended in the fluid, and they appear on the canvass like sand, which nothing can fix or unite,

"The *second* condition is, That the materials of which colours are composed do not bear too near an affinity with the phlogistic vapour. The experiments to which I submitted whites from lead, is an infallible means of ascertaining the quality of colours in this respect, without waiting for the slow impression of time.

"A *third* condition equally essential is, That the colouring body be not volatile, that it be not connected with a substance of a weak texture, susceptible of a spontaneous degeneracy. This consideration excludes the greater part of substances which have received their tints from vegetable organization; at least it makes it impossible to incorporate their finer parts with a combination more solid.

"After these reflections, my researches were directed, first, to the five pure earths; next, to the earthy compounds; in the third place, to the earthy salts, which can scarcely be dissolved; lastly, to the metallic earths, either pure or precipitated by Prussian alkali. M. Wenzel has discovered a sixth earth, which I call *eburne*, and which, after

other experiments, I thought of applying to the purposes of painting; but I soon perceived that it would have the same fault with other kinds of earth, and, besides, that it could not be obtained but at a very considerable expense.

"The five pure earths possess fixity in a very great degree, and at the same time are little affected by the phlogistic vapour; but they refuse to unite with oil or mucilages, and the white is totally extinguished when it is ground with these liquids. I made several attempts on earth from alum, not only because M. Beaume recommended the use of it in painting, and because it enters into the composition of Prussian blue, but also because it is a chief ingredient in ochres, and other earths of that nature, which supposes that it should unite in a certain degree with diluting liquors; notwithstanding, in whatever manner I treated it, it would not yield a white; but one will be less surprized at this want of success, when he considers, that in the ochres and Prussian blue, the earth from alum is only the vehicle of the colouring body, whereas here it is the colour itself.

"To be convinced of the truth of this observation, it is only necessary to mix equal parts of this earth, or even of clay not coloured, with ceruse or any other white: the mixture will be susceptible of being ground in oil or in gum without being extinguished; it will easily unite with any coloured substance, and be productive of no bad consequences to the pure earths.

"Nature and art present to us a considerable number of earthy compositions sufficiently white for the purposes of painting; such as the jasper white, the feldspar white, the schirl white, &c. But all these substances, in all the trials which I made, had the fault which I have already mentioned; and originating from the same cause, they wanted a fixed colouring body, which would not change when it is pulverized, nor be extinguished when it is diluted.

"The ultramarine blue, which is extracted from the blue jasper, and known by the name of lapis lazuli, seems at first view to warrant the possibility of appropriating to painting all the opaque half-vitrified compositions of the nature of jasper.

"Prepossessed with this idea, I conceived the hope of producing a true white lapis; but I soon perceived that the experiment confirmed the principle which I had laid down from my observations on pure earths; since it is not the substance peculiar to the jasper which constitutes the ultramarine blue, but the metallic substance which accidentally colours this particular kind of jasper.

"In the same manner art, in this imitation of nature, should have

for its object to give a permanent base to colour already formed, to fix it without altering, and to augment perhaps its splendor and its intensity, without attempting to produce a colour.

"In excepting from earthy and metallic salts all those of which the acid is not completely saturated, which would easily attract the humidity of the air, or which would be easily dissolved, you have but a very small number to make experiments on.

"The natural and artificial *selenite* gives, with oil, a paste without colour, and tasting somewhat like honey; its white is better preserved with a gum, but even in this case it resembles a half transparent pap.

"The natural or regenerated *spat perant*, as it is technically called, is the most likely salt to produce white. As it is of all others the most difficult to dissolve, it appears after pulverization to be a very fine white, but is scarcely touched with oil when it becomes grey and half transparent: the mucilage alters it also, although less discernibly; and it does not even resume its white colour after it becomes dry on the canvass.

"The same is the case with *calcareous borax*, formed by the dissolution of borax in lime-water; its white is completely extinguished with oil, less so with gum; but it hardens so instantaneously with the latter, that it is impossible ever to dilute it again.

"Calcareous tartar, obtained by casting quick lime into a boiling dissolution of cream of tartar, is affected with oil in the same manner as selenite; but with mucilaginous water it gives a pretty good white, only possessed of little reflection, and appearing like plaster; it applied very well to the canvass, and resisted the phlogistic vapour.

"According to M. Weben, in his work intitled *Fabrien and Kunste,* published 1781, the white called in Germany *krembser wiess,* is nothing but the vitriol of lead, prepared by dissolving lead in nitrous acid, and precipitating it in vitriolic acid; and forming it afterwards into solid tablets by means of gum water. It is certain that this resembles in no shape the white called in France the white of crems; at least I never found that it could be dissolved in vinegar; but I tried the white prepared in M. Weben's manner, and the result was the same as above, that is to say, it turned completely black.

"The vitriols of lead and of bismuth alter more speedily than the calces of those metals. And thus, with the exception of calcareous tartar, which may be of some use in water-colours, the best earthy salts on which I have made experiments, may all, or the most of them, give a base to some colours, but cannot constitute by themselves a colour useful in painting.

"Of the fifteen known metallic substances there are nine which yield white calces: namely, silver, mercury, lead, tin, antimony, bismuth, zinc, arsenic, and manganese.

"Of these nine substances, we may almost pass over silver and mercury; because, though they yield a very fine white, precipitated by means of crystallized vegetable alkali, yet it is soon altered when exposed to the air; that from silver changing into black, and that from mercury changing into yellow.

"It is well known that lead gives a very good white, and one which unites easily with oil or size; but that it is extremely liable to change, has been my principal object to prove; and the experiments which I have made place it beyond contradiction.

"I shall only add, that if there is a preparation able to correct this fault, it should be the precipitation of the earth of this metal in its acetous dissolution by Prussian alkali; but the white which results from this preparation becomes sensibly brownish when it is exposed a few minutes only to the phlogistic vapour.

"It would be therefore unreasonable to persevere in the use of this substance, or to wish to render it fixed, since the changes which it undergoes do not alter its nature, and the indestructible order of its affinities.—The calx of tin is easily applied to any purpose, and experiences no change from the concentrated phlogistic vapour. These considerations induced me to endeavour to obtain this calx perfectly white; and here follows the result of my operations: the tin of calcined *melac* gives a pretty white calx; but whatever attention I paid to take off the red surface which the violence of the fire occasioned, it takes always a shade of grey when it is diluted. Tin calcined by nitre in fusion, gives a tarnished and gross calx, which multiplied washings could not deprive of a yellowish tint.

"Having precipitated, by means of crystallised vegetable alkali, a dissolution of English tin, which had been made in the muriatic acid after the manner of M. Bayen to extract the arsenic, I had a calx of the greatest whiteness, so light that it buoyed up to the surface of the liquor, and so thin that the greater part of it passed through the filter; but it experiences at the same time a kind of adherence with the salts, which makes the part of it retained by the filter incapable of being pulverised, gummy, semi-transparent, and even a little changed into yellow. In this condition it is destroyed when diluted; it is necessary, therefore, to moisten it in boiling water, and afterwards to calcine slightly the sediment after it has had sufficient time to settle.

"I have tried the calcination by means of moisture, in employing

the tin of the purest melac, and a rectified nitrous acid, according to the method of Meyer. It formed a very white sparkling calx, which remained in the filter in the consistency of jelly.—Meanwhile, I observed that it was always a little yellow by the mixture of a portion of that earth which took, in the operation, the colour of a turbid mineral.

"A very fine white calx is extracted from antimony, calcined by nitre in fusion; but the earth of this semi-metal must be placed in the number of those which combine too easily with the phlogistic vapour. The diaphoretic antimony, ground in oil, took in ten minutes in my phlogistic apparatus a colour somewhat like sulphur.

"The property of bismuth to give a very fine white calx, known by the name of *magistery*, or white sard, is generally known; it is easily prepared, since it is only necessary to dissolve the bismuth in nitrous acid, and to precipitate the dissolution by pure water; it dilutes perfectly with oil and mucilages. But this colour ought to be rejected, as the most alterable by the phlogistic vapour. It became completely black in ten minutes in my apparatus; and this fact is also proved from what happens to females who use this colour, when they are exposed to the vapours of sulphur, of garlic, or of any putrid substances.

"Zinc furnishes by all the processes of calcination and precipitation a pleasing white calx, when it is pure and separated from iron; otherwise the dissolutions of the vitriol of zinc will become yellow when exposed to the air. I have precipitated those solutions by lime-water, by caustic, and effervescent alkalis; I have calcined this semi-metal alone and with nitre; and in all those operations I have obtained an earthy substance of different degrees of whiteness, which, after it was dried and prepared, mixed readily with oil and mucilages without losing its colour; and which experienced no sensible change when exposed to the phlogistic vapour.

"These valuable properties, the chief object of my researches, engaged me to multiply my experiments, to determine at once the most economical process, and the most advantageous and infallible preparation. These attempts have convinced me, that the calcination of this semi-metal alone in a crucible, placed horizontally on the corners of a reverberating furnace, gives the purest, the whitest, and the least reducible calx; and that to make an excellent colour, it is sufficient to separate the parts not burned with water, and grind it with a little of the earth of alum or chalk to give it a body. Zinc precipitated in Prussian alkali, even in distilled vinegar, retains always a shade of yellow, does not unite so well in oil, and takes a semi-transparent consistence like cheese.

"White arsenic loses its opacity much less in diluting than one would believe from its saline nature; it preserves its colour best in gum-water; and it is remarkable, that instead of turning black in the phlogistic vapour, it takes a very distinct shade of yellow. This property is sufficiently singular and constant to furnish a new method of analysing arsenic, so as to know it. And this alteration of colour makes it of no use in painting, although its deleterious qualities did not forbid the practice.

"The semi-metal known by the name of *manganese* give also a white calx. I had at first great hopes from this colour, as, contrary to all those extracted from the other metals, it became white by the phlogistic vapour There remained, therefore, but one difficulty to overcome, viz. to separate from the manganese the portion of iron which it usually contained, and which infallibly makes the earth a little yellow. To accomplish this in the cheapest manner, I submitted the black ore of the manganese to a long calcination to render its iron insoluble; I afterwards applied vinegar to it, after the example of M. de la Peyrouse; and in precipitating the dissolution by effervescent alkali, I easily obtained a pure white precipitate. But I soon perceived that the facility with which a colouring body loses its phlogiston, is no less an inconveniency than that of attracting it, and productive of the same alterations.

"The white of manganese became very soon yellow when exposed to the air; and this is not to be ascribed to the iron contained in it, since neither the galls nor Prussian alkali had discovered any of it in the solution. This substance, therefore, can be of no use in producing a white colour for painting."

The experiment by which M. de Morveau tried the colours not alterable by the phlogistic vapour, was performed before the academy, the prince of Conde being president. "I placed (says he) in my apparatus pieces of cloth, on which were laid the white of calcareous tartar in water, different preparations of white from tin and zinc, in oil and water: and I allowed them to continue exposed to the phlogistic vapour during a sitting of the academy; if they were not altered, their superiority over the whites in use would be sufficiently established. The sitting continued for near an hour; and the bottle having been opened, all the colours continued to have the same shade which they had before. I can, therefore, recommend to painters those three whites, and particularly that of zinc, the preparation of which is exposed to less variation, the shade more lively and uniform, and moreover it is fit for all purposes, and perhaps procured at less expense.

"I will assert farther, that it may be procured in sufficient quantities to supply the place of ceruse in every branch of the art, even in interior house building:—I would recommend it, less with the view of adding new splendor to this kind of ornament, than for the safety of those who are employed in it, and perhaps for the safety of those who inhabit houses ornamented in this manner.

"But without being too sanguine, although the processes in the fabrication be simplified in proportion to the demand, as is usually the case, yet there is reason to apprehend, that the low price of ceruse will always give it the preference in house-painting. With regard to those who apply colours to nobler purposes, they will not hesitate to employ the white of zinc. I am assured that four franks is paid for the pound of white of crems; and I believe the white in question, prepared in the manner which I have pointed out, might be sold for six.

"M. Courtois, connected with the laboratory of the academy, has already declared that it is used for house-painting; less, however, in regard to its unalterability, than to its solubility: and this can be the more readily believed, as the flower of zinc enters into many compositions of the apothecary. The same gentleman has arrived at the art of giving more body to this white, which the painters seemed to desire, and also of making it bear a comparison with white lead either in water or oil. The only fault found with it, is its drying slowly when used in oil; but some experiments which I have made, incline me to believe that this fault may be easily remedied, or at least greatly corrected, by giving it more body. At any rate, it may be rendered siccative at pleasure, by adding a little vitriol of zinc or copperas slightly calcined.

"Painters already know the properties of this salt, but perhaps they do not know that it mixes with the white of zinc better than with any other colour; the reason is, they have chemically the same base. It is prepared by purging the white copperas of that small portion of iron which would render it yellow; and this is easily done in digesting its solution, even when cold, on the filings of zinc.

"The mixture of this salt thus prepared is made on the pallet, without producing any alteration, and a small quantity will produce a great effect."

Mr. Vanherman has lately laid before the Society of Arts, a method of rendering fish oil applicable to painting; and it appears to make a good and cheap vehicle for colours exposed to the weather, though it dries but slowly. To thirty-two gallons of vinegar he adds twelve pounds of litharge and twelve pounds of sulphate of zinc, shaking the

mixture well twice a-day for a week. The mixture is then put into a tun of fish-oil, with which it is well shaken and mixed, and the next day the clearer part, about seven-eighths of the whole, is poured off. Twelve gallons of linseed-oil and two of oil of turpentine are then added to the clear part, and this being well shaken together, is left to settle for two or three days, when it will be fit to grind white lead and all fine colours in: these, however, are to be thinned for use with linseed oil and oil of turpentine. For cheap paints exposed to the weather, whiting and road dirt finely sifted are to be mixed with lime water to the consistence of mortar. To this composition may be added almost any pigment ground with the sediment of the prepared oil, in the proportion of one part to two of the lime water already used, and the whole is to be thinned for use, by adding to every eight pounds a quart of linseed oil, and as much of a mixture of the prepared oil with lime water. The proportions of the mixture are not mentioned. If two ounces of litharge be added to a gallon of linseed oil and well shaken every day for a fortnight, and the clearer part mixed with half a pint of oil of turpentine be exposed to the sun for two or three days in shallow pans, Mr. Vanherman says, "it will be as white as nut oil." If half a pound of frankincense be dissolved in a quart of oil of turpentine, and added to a gallon of this bleached oil, and white lead ground in oil of turpentine be thinned for use with the mixture, he asserts, that it will be quite dry and void of smell in four hours.

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12 ditto linseed-oil,
2 ditto spirits of turpentine,
32 ditto vinegar,

298 gallons, worth 4*s.* 6*d.* per gallon.

Which produces . .	£67	1	0
Deduct the expense .	43	5	0
	£23	16	0 profit.

To prepare the Vinegar for the Oil.

Into a cask which will contain about forty gallons, put thirty-two gallons of good common vinegar; add to this twelve pounds of litharge, and twelve pounds of white copperas in powder; bung up the vessel; and shake and roll it well twice a day for a week; when it will be fit to put into a ton of whale, cod, or seal oil; (but the Southern whale oil is to be preferred, on account of its good colour, and little or no smell) shake and mix all together, when it may settle until the next day; then pour off the clear, which will be about seven-eights of the whole. To clear this part add twelve gallons of linseed-oil, and two gallons of spirits of turpentine; shake them well together, and after the whole has settled two or three days, it will be fit to grind white-lead, and all fine colours in; and, when ground, cannot be distinguished from those ground in linseed-oil, unless by the superiority of its colour.

If the oil is wanted only for coarse purposes, the linseed-oil and oil of turpentine may be added at the same time that the prepared vinegar is put in, and after being well shaken up, is fit for immediate use without being suffered to settle.

The vinegar is to dissolve the litharge, and the copperas accelerates the dissolution, and strengthens the drying quality.

The residue, or bottom, when settled, by the addition of half its quantity of fresh lime-water, forms an excellent oil for mixing with all the coarse paints for preserving outside work

Note.—All colours ground in the above oil, and used for inside work, must be thinned with linseed-oil and oil of turpentine.

The oil mixed with lime-water, Mr. Vanherman calls *incorporated oil.*

The method of preparing, and the expense of the various Impenetrable Paints.

First.—*Subdued Green.*	£.	s.	d.
Fresh lime-water, 6 gallons	0	0	3
Road dirt finely sifted, 112 pounds	0	1	0
Whiting, 112 ditto	0	2	4
Blue-black, 30 ditto	0	2	4
Wet blue, 20 ditto	0	10	0
Residue of the oil, 3 gallons	0	6	0
Yellow ochre in powder, 24 pounds	0	2	0
	£1	4	1

This composition will weigh 368 pounds, which is scarce one penny per pound. To render the above paint fit for use, to every eight pounds add one quart of the incorporated oil, and one quart of linseed-oil, and it will be found a paint with every requisite quality, both of beauty, durability, and cheapness, and in this state of preparation does not exceed two-pence-halfpenny per pound; whereas the coal tar of the same colour is six-pence.

The method of mixing the ingredients for the Subdued Green.

First, pour six gallons of lime-water into a large tub, then throw in 112 pounds of whiting; stir it round well with a stirrer, let it settle for about an hour, and stir it again. Now the painter may put in the 112 lbs. of road dirt, mix it well, then add the blue-black, after which the yellow ochre, and when all is tolerably blended, take it out of the tub and put it on a large board or platform, and with a labourer's shovel mix, and work it about as they do mortar. Now add the wet blue, which must be previously ground in the incorporated oil (as it will not grind or mix with any other oil). When this is added to the mass, you may begin to thin it with the incorporated oil in the proportion of one quart to every eight pounds, and then the linseed-oil in the same proportion, and it is ready to be put into casks for use.

Lead Colour.

	£.	s.	d.
Whiting, 112 pounds	0	2	4
Blue-black, 5 ditto	0	1	8
Lead ground in oil, 28 ditto	0	14	0
Road dirt, 56 ditto	0	0	6
Lime-water, 5 gallons	0	0	6
Residue of the oil, 2½ ditto	0	5	0
Weighs 256 lbs.	£1	4	4

To the above add two gallons of the incorporated oil, and two gallons of linseed oil to thin it for use, and it will not exceed 1½ per pound.

Note.—The lime-water, whiting, road dirt, and blue-black, must be first mixed together, then add the ground lead, first blending it with two gallons and a half of the prepared fish-oil, after which thin the whole with the two gallons of linseed-oil, and two gallons of incorporated oil, and it will be fit for use. For garden doors, and other work

liable to be in constant use, a little spirits of turpentine may be added to the paint whilst laying on, which will have the desired effect.

Bright Green.

	£.	s.	d.
112 pounds yellow ochre in powder, at 2*d*. per lb.	0	18	8
168 ditto road dust	0	1	8
112 ditto wet blue, at 6*d*. per pound	2	16	0
10 ditto blue-black, at 3*d*. ditto	0	2	6
6 gallons of lime-water	0	0	6
4 ditto fish-oil prepared	0	12	0
7½ ditto incorporated oil . . . . ,	0	15	0
7½ ditto linseed-oil, at 4*s*. 6*d*. per gallon . .	2	8	9
592 lbs. weight.	£7	15	1

This excellent bright green does not exceed three-pence farthing per pound ready to lay on, and the inventor challenges any colour-man or painter, to produce a green equal to it for eighteen-pence.

After painting, the colour left in the pot may be covered with water to prevent it from skinning, and the brushes, as usual, should be cleaned with the painting knife, and kept under water.

A brighter green may be formed by omitting the blue-black; and

A lighter green may be made by the addition of ten pounds of ground white-lead.

A variety of greens may be obtained, by varying the proportions of the blue and yellow.

Observe that the wet blue must be ground with the incorporated oil, preparatory to its being mixed with the mass.

Stone Colour.

	£.	s.	d.
Lime-water, 4 gallons	0	0	4
Whiting, 112 pounds	0	2	4
White-lead, ground, 28 pounds, at 6*d*. per lb. .	0	14	0
Road dust, 56 pounds	0	0	6
Prepared fish-oil, 2 gallons	0	6	0
Incorporated oil, 3½ gallons	0	7	0
Linseed oil, 3½ ditto	0	15	9
Weighs 293lbs.	£2	5	11

The above stone-colour, fit for use, is not two-pence per pound.

Brown Red.

	£.	s.	d.
Lime-water, 8 gallons	0	0	8
Spanish brown, 112 pounds	1	0	0
Road dust, 224 pounds	0	2	0
4 gallons of fish-oil	0	12	0
4 ditto incorporated oil	0	8	0
4 ditto linseed oil	0	18	0
Weighs 501 lbs.	£2	0	8

This most excellent paint is scarcely one penny per pound. The Spanish brown must be in powder.

A good chocolate colour is made by the addition of blue-black, in powder, or lamp-black, till the colour is to the painter's mind; and a lighter brown may be formed by adding ground white-lead.

Note.—By ground lead, is meant white-lead ground in oil.

Yellow is prepared with yellow-ochre in powder, in the same proportion as Spanish brown.

Black is also prepared in the same proportion, using lamp-black or blue-black.

To whiten Linseed Oil.

Take any quantity of linseed oil, and to every gallon add two ounces of litharge; shake it up every day for fourteen days, then let it settle a day or two; pour off the clear into shallow pans, the same as dripping-pans, first putting half a pint of spirits of turpentine to each gallon. Place it in the sun, and in three days it will be as white as nut oil.

This oil, before it is bleached, and without the turpentine, is far superior to the best boiled oil, there being no waste or offensive smell.

Mr. Rawlinson, of Derby, has been rewarded by the Society of Arts, for the invention of a colour-mill, of a peculiar kind, which it may be proper to illustrate by reference to an engraving.

Plate II. Fig. 3. A is the roller or cylinder, made of any kind of marble; black marble is esteemed the best, because it is the hardest, and takes the best polish. B is the concave muller, covering one-third of the roller, and of the same kind of marble, and is fixed in a wooden frame *b*, which is hung to the frame E at *i i*. C is a piece of iron, about an inch broad, to keep the muller steady, and is fixed to the frame with a joint at *f*. The small binding screw, with the

Fig. 1.

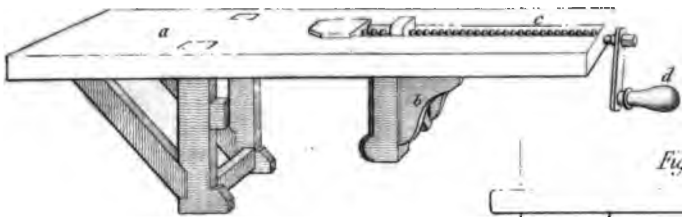


Fig. 2.

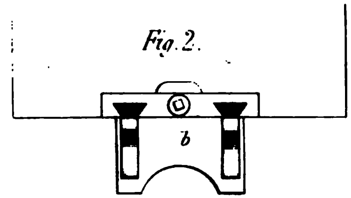


Fig. 3.

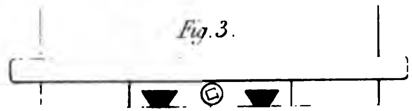


Fig. 5.

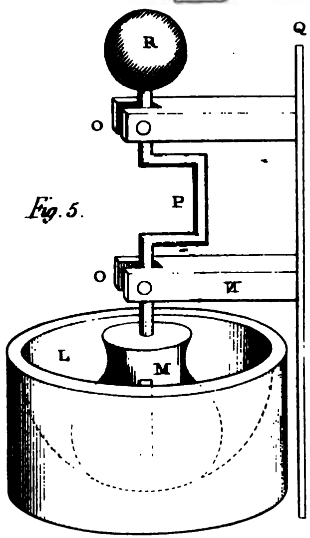


Fig. 6.

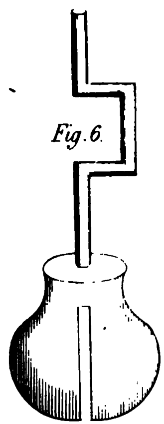
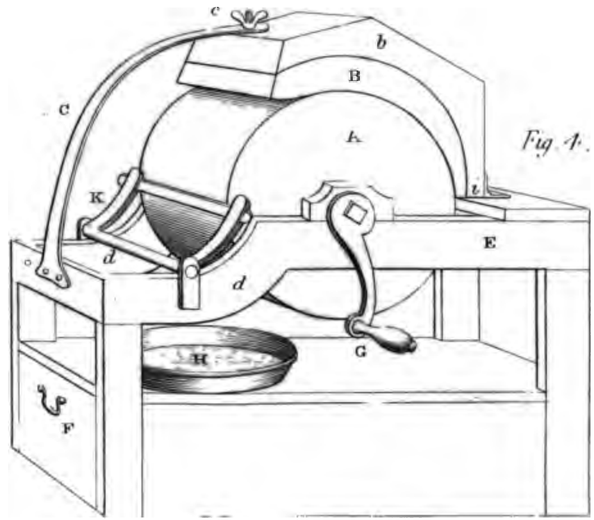


Fig. 4.



C. Gladwin. Sculp.

flynut, that passes through the centre of the iron plate at *c*, is for the purpose of laying more pressure on the muller, if required, as well as to keep it steady. D is a taker off, made of a clock-spring, about half an inch broad, and fixed similar to a frame-saw in an iron frame *k*, in an inclined position to the roller, and turning on pivots at *d d*. G is a slide-board to draw out occasionally, to clean, &c. If any particles of paint should fall from the roller, and which also forms itself for the plate H, to catch the colour on as it falls from the taker off. F is a drawer, for the purpose of containing curriers' shavings, which are the best things for cleaning paint-mills. E is the frame.

Previous to the colour being applied to the mill, I should recommend it to be finely pulverized in a mortar, covered in the manner of the chemists when they levigate poisonous drugs. This process of dry-grinding is equally necessary for the marble slab now in use, after which it should be mixed with oil or water, and with a spatula or pallet-knife put on the roller, near to the top of the concave muller, and the roller turned round, which takes the colour under the muller without any difficulty, and very few turns of the roller spreads it equally over its surface. When it is perceived sufficiently fine for the purpose required, it is very easily taken off by means of the taker-off described, which must be held against the roller, and the roller turned the reverse way, which cleans it very quick and very completely; and the muller will only require to be cleaned when you desist or change the colour. It is then turned back, being hung on pinions to the frames at *i i*, and cleaned with a pallet-knife or spatula very conveniently. Afterwards, a handful of curriers' shavings held on the roller, with two or three revolutions, cleans it effectually; and there is less waste with this machine than with any marble-slab.

As to the quantity ground at once on this mill, it must be regulated by the state of fineness to which it is required to be ground. If it is wanted to be very fine, a smaller quantity must be put on the roller at a time; and as to time requisite for grinding a given quantity of colour, this will also depend on the state of fineness to which it is to be ground.

It may be useful now to advert to a plan by which the labour of three men out of four may be saved in grinding by hand, with the common colour-mills. One mill has ever been considered sufficient for one man to turn, whereas one man can now with perfect ease, turn four mills. This is effected by placing two mills on each side of the winch, so close as only to leave room for the fly-wheel to play between them. The spindles of each on either side are locked together by a

small iron collar with a pin passing through it. The distance from each other, of the mills thus paired, (in order that the man may stand between them to turn,) is two feet six inches. The distance of the arms of the winch screwed on the end of the spindles on either side, is two feet two inches; the length of the arm is one foot six inches from the spindles to the bar across which the man clasps; in order to turn, fly-wheels at the extremity are only impediments. When the mills are arranged as described, it can scarcely be believed with what ease they are moved. If a little extraordinary motion is given them, and they are then left alone, they will continue to go round sixteen times; hence they may be turned by a man with one hand.

We shall now proceed to note what is requisite for the painting of new walls or stucco, not painted before, and prepared for oil colours.

It does not appear that any painting in oil can be done to any good or serviceable effect in stucco, unless not merely the surface appear dry, but that the walls have been erected a sufficient time to permit the mass of brick-work to have acquired a sufficient degree of dryness. When stucco is on batten-work it may be painted over much sooner than when prepared as brick. Indeed the greatest part of the mystery of painting stucco, so as to stand or wear well, certainly consists in attending to these observations; for whoever has observed the expansive power of water, not only in congelation, but also in evaporation, must be well aware that when it meets with any foreign body obstructing its escape, as oil painting for instance, it immediately resists it, forming a number of vesicles or particles, containing an acrid lime-water, which forces off the layers of plaster, and frequently causes large defective patches, extremely difficult to get the better of.

Perhaps, in general cases, where persons are building on their own estates, or for themselves, two or three years are not too long to suffer the stucco to remain unpainted; though frequently in speculative works as many weeks are scarcely allowed. Indeed, there some nostrums set forth, in favour of which it is stated, in spite of all the natural properties of bodies, that stucco may, after having been washed over with these liquids, be painted immediately with oil colours. It is true there may be instances, and in many experiments some will be found that appear to counteract the general laws of nature; but on following them up to their causes, it will be found otherwise.

Supposing the foregoing precautions to have been attended to, there can be no better mode adopted for priming and laying on the first coat on stucco, than by linseed or nut oil, boiled with dryers, as

before mentioned, with a proper brush; taking care, in all cases, not to lay on too much, so as to render the surface rough and irregular, and not more than the stucco will absorb. It should then be covered with three or four coats of ceruse, or white lead, prepared as described for painting on wainscoting, letting each coat have sufficient time to dry hard: if time will permit, two or three days betwixt each layer will not be too long.

If the stucco be intended to be finished of any given tint, as gray, light green, apricot, &c. it will then be proper, about the third coat of painting, to prepare the ground for such tint, by a slight advance towards it.

Gray is made of ceruse; Prussian-blue, ivory-black, and lake, sage-green, pea, and sea-green, with white; Prussian-blue and fine yellows, apricot and peach, with lake; white, Chinese vermilion, and fine yellow, fawn-colour, with burnt terra de Sienna, or umber and white; olive greens, with fine Prussian-blue and Oxfordshire ochre.

Painting in distemper, or water colours mixed with size, stucco, or plaster, which is intended to be painted in oil when finished, but not being sufficiently dry to receive the oil, may have a coating in water colours, of any given tint required, in order to give a more finished appearance to that part of the building.

Straw colours may be made with French-white, a ceruse, and masticot, or Dutch-pink; fine grays with some whites and refiners' verditer; an inferior gray may be made with blue-black, or bone-black, and indigo; Pea-greens, with French-green, Olympian-green, &c.; fawn-colour, with burnt terra de Sienna, or burnt umber, and white: and so of any intermediate tint. The colours all should be ground very fine, and incorporated with white, and a size, made of parchment, or some similar substance, isinglass being too expensive for common works.

It will not require less than two coats of any of the foregoing colours in order to cover the plaster, and bear out an uniform appearance. It must be recollected, that when the stucco is sufficiently dry, and it is desirous to have it painted in oil, the whole of the water colour ought to be removed, which may be easily done by washing; and when quite dry proceed with it after the directions given in oil painting of stucco.

When old plastering has become discoloured by stains, and it be desired to have it painted in distemper, it is then advisable to give the old plaster, when properly cleaned off and prepared, one coat, at least, of white lead ground in oil, and used with spirits of turpentine, which

will generally fix all old stains, and when quite dry will take the water colours very kindly.

Graining is understood among painters, to be the imitating of the several different species of scarce woods, such as are used for the best articles of furniture, viz. satin-wood, rose-wood, king-wood, mahogany, &c. &c. Imitations of this nature, when well performed, are calculuted to give a zest to painting: at Paris, every species of wood-work used in their houses, as a part of the building, is done in this manner. The dead-white so much in vogue amongst us is not practised there. To grain satin-wood a ground is previously laid, composed of Naples yellow and ceruse, diluted with oil of turpentine, this is spread very evenly over the work to be grained, and is then left a day or two to get fixed and dry. The painter then prepares his pallet-board with small quantities of the same yellow and ochre, with a little brown, having some boiled oil and oil of turpentine mixed together, to saturate the colours to be used in the operation. He is also provided with several different sized camels' hair pencils, and also with one or more *flat* hogs' hair brushes. When he has mixed the colours, he spreads it over a pannel, or any other small part of the work, first, to see the effect of the tints, and if it suit what he is about to perform, he perseveres by doing a pannel at a time; and, in the instance of doors and other framing, the pannels are done first, and the margins round them afterwards. The flat hogs' hair brushes, by being dipped in the mixture of oil and turpentine, and drawn down the newly-laid colour, occasions the shades and grainings in it: this effect takes place in the colour from the brush supplying an excess of saturation to the colour it touches; and to produce the mottled appearance, the camels' hair pencils are applied, and when it is all finished, it is left to fix and dry, after which it is covered by a coat or two of good oil-varnish. The other fancy-woods are performed in a similar manner, the painter varying the colours to produce them only. Some of our painters are so expert at this kind of imitation, and also in that of marbles, as to prevent their easy detection, except by the touch.

Ornamental Painting embraces the executing of friezes and the decorative parts of architecture in chiara-obscura, or light and shade on walls and ceilings. It requires, in the first place, a ground to be well painted of the tint it is proposed to remain, and exactly drawn into the width it is intended to be left on such a ground so formed. The ornament to be painted is to be drawn out neatly with a black-lead pencil, and then to be painted and shaded, to give it its due effect.

Such kind of painting is often painted on slips of paper, or Irish

cloth, and pasted up afterwards; some artists also, to facilitate their work, and when the ornament is of a similar pattern all through, do it by what is termed *stinselling;* this method consists in drawing out a certain length of the pattern to be painted, very accurately on paper, and then pricking a large-sized needle in regular distances all round the pattern through the paper, which they afterwards lay smoothly against the wall to be ornamented and strike its outer surface, which has been pricked through with a small linen bag containing powdered chalk, the powder enters the apertures in the pattern, and fixes itself against the wall, exhibiting the exact outline of the ornaments which the painter immediately fixes by painting it on the wall; by this means a great saving of his time is accomplished. Some paintings in this manner are heightened with gold: this is performed after the ornament is painted in, as it is termed, by the process known as Gilding in Oil.

Letter or Inscription Writing is performed by persons known in the trade as letter-writers. The process is similar to ornament painting, excepting the superior ability and taste required in the one, whereas the other is a mere mechanical operation. The letter-writer sketches out in pencil the words he has to write, and afterwards corrects the outline by the colour which he applies with a camels' hair pencil. When the letters are to be gilt, the process is similar, and as the letters are painted, they are covered with leaf gold, and when completely covered it is left to fix itself by the drying of the painting on which it has been laid. After which, a sponge and water is used to clear away the superfluous gold; the whole is then covered by a coat of good oil varnish. Letter-writing is charged by the inch, viz. the height of one of the letters being taken, will, by being multiplied by the number on the whole inscription, denote exactly the quantity of inches which has been written. The price varies in as much as shadowed letters are a half-penny an inch more than plain ones, and gilt letters are treble the price of either. *Two-pence* an *inch* is about the average price of inscription letters.

The machine employed by *glaziers* is liable to several objections, and we gladly give place to an improved apparatus for their use.

Fig. 1. Plate II. represents the machine; the part *a* is similar to that used by glaziers, which is placed on the outside of the window; *b* is an additional moving-piece, which presses against the inside of the window-frame, and is brought nearer to, or removed farther from it, by means of the male-screw *c*, and its handle *d*.

Fig. 2. shows the lower part of a window, and the manner in which

the moving-piece *b*, including a female-screw, acts against the inside of the window-frame.

Fig. 3. shows a cross-bar introduced in the place of the moving-piece last mentioned, which bar extends from one window side to the other, and explains how the machine may be used, where any injury might arise from screwing the moving-piece in the centre of the recess of the window.

The general improvement consists in the use of a screw on that end of the frame which is within the house, and which keeps the machine steady and firm, instead of the two upright irons, which are put through holes made in the top plank of the machine, in the common mode, and which occasion the machine to be very unsteady in use, and liable to accident. There are two blocks marked *d d*, in fig. 4, which may be occasionally put in, or taken out, according as the stone-work under the window may require.

The business of the *plumber* must now briefly engage our attention. This artizan chiefly works in lead; a metal known in the arts, from its durability, maleability, and many other properties, which renders it of the very highest importance. Lead is of a bluish-white colour, and, when newly melted, very bright, but it soon becomes tarnished by exposure to the air. Its hardness is $5\frac{1}{2}$, its specific gravity is 11,3523. It may be reduced by the hammer to very thin plates, it may also be drawn out into wire; but its tenacity is not great if compared with many of the other metals. A lead wire $\frac{1}{120}$ inch diameter is capable of supporting 18:4 pounds only without breaking. Lead melts when heated to the temperature of 612 of Fahrenheit, and when a strong heat is applied the metal boils and evaporates. If it be cooled slowly it crystallizes. When exposed to the air it soon loses its lustre, and acquires at first a dirty grey colour, and, finally, its surface becomes almost white. This is owing to its gradual combination with oxygen, and conversion into an oxide; but this conversion is exceedingly slow. The external crust which forms first, preserving the rest of the metal for a long time, from the further action of the air. Water has no direct action upon lead, but it facilitates the action of the external air; for when lead is exposed to the air, and kept constantly wet, it is oxidated much more rapidly than it otherwise would be. Hence the reason of the white crust which appears upon the sides of leaden vessels containing water just at the place where the upper surface of the water terminates.

Milled Lead.

Lead is obtained from the mines, and is almost always combined with sulphur, and hence it is called a *sulphuret*. The operation of roasting the ore, or smelting, as it is called, to obtain the pure metal consists :—1. In picking up the mineral to separate the unctuous, rich, or pure ore, and the stony matrix, and other impurities. 2. In pounding the picked ore under the stampers. 3. In washing the pulverized ore to carry off the matrix by the water. 4. In roasting the mineral in a reverberatory furnace, taking care to stir it, to facilitate the evaporation of the sulphur. When the surface begins to become of the consistence of paste, it is covered with charcoal, the mixture is shaken, the fire increased, and the lead then flows down on all sides to the bottom of the basin of the furnace, from which it is drawn off into moulds or patterns, prepared to receive it. The moulds are made so as to take a charge of metal equal to one hundred and fifty-four pounds; these are called, in commerce, *pigs*, or pigs of lead, and are exported, and sold as such at the depots, by the lead merchants.

The plumbers use lead in sheets, and of these they have two kinds; one of which they call *cast*, and the other *milled lead*. The cast lead is used for the purpose of covering the flat roofs of terraces of buildings, forming gutters, lining reservoirs, &c. In architecture it is technically divided into 5, 5½, 6, 6½, 7, 7½, 8, and 8½ lbs. cast-lead, by which is understood, that to every *foot* superficial of such cast-lead, it is to contain these several weights of metal in each respectively; so that an architect when directing a plumber to cover or line a place with cast sheet-lead, tells the workman that "it is to be done with 6 or 7lb. lead;" meaning by it, that he expects each foot superficial of the metal to be equal in weight to six, seven, or other number of pounds. The plumbers sometimes attempt deception in this arrangement, and particularly in work agreed for by contract, by putting down a lighter metal than the one they have engaged to do. The writer of this article has once or more had occasion to interfere in such attempts, and has had the whole of such lead removed, not finding it adequate in weight per foot to that which was contracted for.

Every plumber, who conducts business to any extent, casts his sheet-lead at home; this he does from the pigs, or from old metal which he may have taken in exchange. The ductility of lead renders it easily to be run, which they do with considerable address. To perform which they provide a copper, well fixed in masonry, and placed at one end of their casting-shop, and near to the mould or casting-table. The casting-table is, generally, in its form, a parallelogram, varying in its size from six feet in width to eighteen or more feet in length. It is raised

from the ground as high as to be about six or seven inches below the top of the copper which contains the metal, and stands on strongly framed legs, so as to be very steady and firm. The top of the table is lined by deal boarding laid very even and firm, and it has a rim projecting upwards, four or five inches all round it. At the end of the table, nearest to the copper in which is the heated lead, is adapted a box equal in length to the width of the table, at the bottom of this is made a long horizontal slit, from which the heated metal is to issue when it is to be cast into sheets. This box moves upon rollers along the edges of the projecting rim of the table, and is set in motion by ropes and pulleys fixed to beams over the table. As soon as the metal is found to be adequately heated, every thing is got ready to cast it on the table, the bottom of which is then covered by a stratum of dry and clean sand, and a rake is applied to smooth it regularly all over the surface. When this is done the box is brought close up to the copper. It must be observed, that these boxes are made, in their contents, equal to the containing of as much of the melted lead as will cast the whole of the sheet at the same time, and the slit in the bottom is adjusted so as to let as much, and no more, out during its progress along the table, as will be sufficient to cover it completely of the thickness and weight per foot required. When the box has dispersed its contents upon the table, it is suffered to cool and congeal, when it is rolled up and removed away, and other sheets are made till all the melted metal in the copper be cast up, and it is emptied. The sheets so formed are rolled up and weighed, as it is by weight the public are charged for sheet-lead.

The other kind of sheet-lead made use of by plumbers, called, in the trade, *milled lead*, is not manufactured at home. This they purchase of the lead merchant, as it is cast and prepared commonly at the ore and roasting furnaces. Such kind of lead is very *thin*, and commonly there is not more than four pounds of metal to the foot superficial. It is used by architects for the covering only of the hips and ridges of roofs of buildings. It is by no means adapted to gutters or terraces, or, in fact, to any part of a building much exposed either to great wear and tear, or the effects of the sun, as it expands and cracks by the latter, and is soon worn away by the former exposure. It is laminated in sheets about the same size as has been described for cast sheet-lead; and, in the operation of making, a laminating-roller is used, or a flatting-mill, which reduces it to the state in which it is seen in commerce.

The greatest proportion of the leaden pipes used in water-works, was, till of late years, made of sheet lead wrapped round an iron or

wooden core, and the joint soldered up. The expense and trouble of this method was considerable, and the pipes thus made were extremely liable to burst at the joint, particularly if bent with a sudden angle. These defects suggested the idea of casting the lead in the form of pipes, by which means the trouble of previously casting and laminating the lead into sheets would be spared, and also the uncertainty of the soldered joints. Such pipes are cast in an iron mould, made in two halves, forming, when put together, a hollow cylinder, of the size of the intended pipe. A core, or iron rod, the size of the bore of the pipe, is adapted to this hollow mould when the halves are put together, and secured by screws or wedges, so that it exactly occupies the centre of the hollow mould, leaving therefore an equal space all round between them. A spout, or entry, for the admission of the melted lead, is made by a corresponding notch cut in each half of the mould, and at another place is a similar vent for the escape of the air. This mould is fixed down upon a long bench; and a rack, moved by toothed wheels and pinions, is fitted up at one end of it, in a line with the centre of the mould. A hook at the end of the rack, being put into an eye at the end of the core of the mould, affords the means of drawing out the core, when the pipe is cast round it by pouring the melted lead into the mould, with the core in it: when the lead is cold, the core is drawn out very nearly to the end of the pipe, by the rack and wheel-work before mentioned. The halves of the moulds are then separated, and the pipe moved along in the mould, so that only an inch or two of its end remains in the mould; the halves of which are again fastened together, with the core between them, and its end entered an inch or two into the first piece of pipe. The mould is now filled with melted lead, the heat of which fuses and unites it with the end of the first piece, so as to double its length. The core is again drawn out a second time, and another length cast to the former. This method produces pipes of any length in one piece, but they are liable to have air-bubbles in them, which produces holes when the metal is thin, and the joinings of the different lengths are not always perfectly sound.

The method which is now very generally adopted, is to cast the lead in an iron mould, upon a cylindrical iron rod of the size for the bore of the intended pipe, the lead being three or four times the thickness of the intended pipe, and in short lengths, which are then drawn through holes in pieces of steel, in the manner of wire-drawing, till the pipe is reduced to the intended thickness, and drawn out to the proper length. Another method is to reduce the pipe by repeatedly passing it through the two rollers of a flatting-mill, in each of which a number

semi-circular notches are formed all round, so that the two rollers, when put together, have a number of circular cavities between them, which gradually diminish in diameter from one end of the rollers to the other. The pipe is first rolled between the largest of these cavities, then in a smaller, and so on to the last, which extends the pipe to its proper length, and diminishes its substance to the proper thickness, at the same time by condensing the metal hardens it, and makes a very strong tube with very little metal. Mr. John Wilkinson, of Brosley, the celebrated iron manufacturer, took out a patent in 1790, for the last mentioned method, which he practised on a very extensive scale: he was not, however, the original inventor, the same thing having been proposed, in 1728, by M. Fayolle; see "Machines Approuves par l'Academie Royale," vol. v. p. 50. Since the expiration of this patent many manufactories of this article have been established, some employing rollers, and others the draw-bench, for extending the pipes.

In 1804, Mr. Alderson took out a patent for lead pipes which were to to be lined with tin, for the conveyance of beer, water, or other fluids, which were in danger of receiving a taint from the corrosion of the lead. This he accomplished by casting a lead pipe in the manner above described, then withdrawing the core, and throwing into the pipe a small quantity of powdered rosin. Another core smaller than the former is next inserted into the centre of the pipe, and melted tin poured in to fill up the space. The pipes are cast in a vertical position, and the rosin melting by the heat floats upon the surface of the tin, and acts as a flux to unite it with the lead. This pipe of lead, lined with tin, is now to be drawn or rolled to length, as before-mentioned. We are informed Mr. Alderson employed rollers to extend them instead of the draw-bench.

Mr. Bramah's method of making lead pipes is very ingenious; it is performed by a process of pumping or forcing the metal in its fluid state, through proper moulds. A boiler or kettle is fitted up over a fire-grate, with flues for the fusion of the metal; in the centre of this boiler a force pump is fixed up, its suction valve drawing in the melted lead contained in the boiler: the forcing pipe of the pump proceeds through the side of the boiler and conducts the lead to the mould, which is fixed on the end of the pipe outside of the boiler: it consists of a tube, bored perfectly smooth and cylindrical, its interior diameter being equal to the outside of the pipe intended to be made; the end of the mould nearest the boiler expands into a conical mouth, larger than the mould itself, and across this widest part a cross bar is fixed, to support a core or mandrel, of a diameter equal to the bore of the intended

pipe, and situated exactly in the centre of the mould, leaving an equal space all round between them: the core is slightly conical, being rather less at its extremity, which terminates at the same length with the external mould. There must be sufficient openings left at the sides of the cross bar supporting the core, to allow the lead to pass freely by, that it may unite again after passing the cross and completely fill the mould. The mould passes through one of the fire flues surrounding the boiler, that it may be kept so hot as to procure the lead in its fluid state, till it arrives nearly at the point of the mould, which is immersed in a cistern of hot water. The operation is simple; the pump, being worked, forces the lead through the mould, the heat and length of which are so regulated, that the lead may chill a little before it quits the extremity of the mould, and issues forth in a solid state into the water cistern, forming a pipe of any length. Mr. Bramah took out a patent for this method in 1797.

Solder is used by the plumber for the purpose of securing the joints of leaden work, in cases in which a *lap* or *roll-joint* cannot be employed. It is a general rule with respect to solder, that it should always be easier of fusion than the metal intended to be soldered by it. Next to this, care must be taken that the solder be as far as it is possible of the same colour with the metal intended to be soldered. Technically, the soft *solder* is that which the plumber makes use of, on account of its melting easily. This solder is composed of *tin and lead,* in equal parts, fused together; after which it is run into moulds in shape not unlike a common gridiron. In this state it is sold by the pound by the manufacturer. In the operation of soldering, the surfaces of the metal intended to be joined are scraped and rendered very clean, they are then brought close up to each other, and, to secure them, they are held by one plumber while another lays a little resin or borax about the joint. This is done to defend the metal, while soldering, from oxidation. The heated solder is then brought in a ladle and poured on the joint to be soldered, and is smoothed and finished by rubbing it about with a heated *grozing-iron,* and when complete, it is filed or scraped off, and made even with the joint and contiguous surface of the lead.

The plumber has no need of a great variety of working tools, as the ductility of the metal he works in does not require them, and what he may require are generally supplied by the master-tradesman. They consist of an iron hammer made rather heavier than they usually are seen, having a short but thick handle. Two or three different sized wooden mallets, and a dressing and flatting tool. This instrument is made of beech wood, commonly about eighteen inches long, and

two inches and a half square, planed quite smooth on one side, and rounded into an arch on the other, or upper side. One of its ends is tapered and rounded to make it convenient to be held in the hand of the workman. With this tool the plumber stretches out and flattens all the sheet-lead, as well as dresses it into the shape it may be wanted in the various purposes to which such lead is applied, using first the flat side of this tool, and then the round side, as may be required. They have also a *jack* and *trying* plane, similar to the same kind of tools used by carpenters. These tools consist of a piece of beech wood, that for the former about sixteen inches, and, for the latter, twenty-two inches long, in each of which a flat iron of sharpened steel is fitted, and held to its work by wooden wedges adapted to mortises made at the distance of about one-third from the fore-end of each plane. At the opposite end is formed a handle by which the planes are worked. With such tools, plumbers plane straight the edges of their sheet-lead, when it is required to present a very regular and correct line, as it is frequently wanted to do in architecture. They are provided also with a line and roller, called a *chalk-line;* with this they line out all the lead into the different widths it may be wanting. Their cutting tools embrace chisels and gouges of different sizes, as well as several cutting knives. These latter are used for the purpose of accurately cutting the sheet-lead into the strips and pieces to the division marked by the chalk-line which has been drawn on the lead. They have files of different sizes, which they use in manufacturing of cistern leads, to pipes, pump-work, &c.

For soldering, they keep a variety of different sized grozing-irons; these are commonly about twelve inches long, and tapered at both ends, the handle-end turned quite round to allow of its being held firmly in the hand while in use. The opposite ends of which are made spherical, and some of them are of a spindle-shape, and of a size in proportion to the soldering to be done with them. These kind of irons are heated to redness when used. Their iron ladles are of three or four sizes, and used for the purpose of heating the solder.

A plumber's measuring rule is of two feet in length, divided into three parts, each of which is eight inches long. Two of its legs are of box-wood, and duodecimally divided, and a third of a piece of slow-tempered steel; this is attached to one of the box legs by a pivot, on which it turns, and the same legs being grooved out on its side it receives the steel leg, when not in use, in this groove. The plumber finds a rule of this description very convenient, inasmuch as he can pass the steel leg of his rule into places he may have to examine, which he could not readily get any thing else to enter; it also answers the

purpose occasionally of removing the oxide or any other matter from off his heated metal. A plumber's rule, by being so made, is constantly in use in one way or another.

Scales and weights are also very essential, as nothing done by the plumber is chargeable till it be weighed. He is also supplied with centre-bits of all sizes, and a stock to work them in, for the making perforations in lead or wood, where he may have occasion to insert pipes, &c. &c. The compasses he uses occasionally, to strike out any circular portion of lead wanted to line or cover figures of that description.

Of laying Sheet-Lead.—The method usually adopted consists, if it be for terraces or flats, of covering such places with a bottom as even as possible, either by boarding or plastering; if by the former, observing to have the boards thick enough to prevent their warping and twisting upwards, as, when this is not attended to, the lead work is soon cracked and becomes very unsightly. The sheets of lead not being more than about six feet in width, make it necessary to have joints when a large surface is to be covered; these joints the plumber manages in various ways to prevent them leaking. The best way is by forming what are called *rolls;* a roll consists of a piece of wood of about two inches square, planed rounding on its upper side, these are fastened under the joints of the lead between the edges of the two sheets which meet together, one of which is dressed up over the roll on the inside, and the other over both of them on the outside, by which means the water is prevented from percolating the flat. No other fastening is required than the adherence of the lead by being closely hammered together, and down upon the flat: indeed, all fastening to the sheet lead, exposed to heat and cold, ought to be avoided, as it expands and shrinks by such vicissitudes, and if secured so as to prevent these from spontaneously effecting it, it will be cracked and dilapidated quickly. When rolls are not used, which is sometimes the case from their being found inconvenient by their projection, *seams*, as they are called, are employed, and consist in simply bending the two edges of the lead which approach to each other up and again over one another, and then dresssing them down close to the flat throughout their whole length. This plan is by no means equal to the one by the roll, either for neatness or security. Soldering the joints is sometimes had recourse to for such kind of work, but it is a very bad way, and no good plumber would recommend it, as lead so fixed will be cracked and leak like a sieve, after having been exposed to one summer's sun. Leaden-flats, as well as gutters, require to be laid with a current to keep them dry. The rule for forming of which consists in giving a fall

rom back to front, or in the way in which it is determined that the sheets of lead are to be laid. A quarter of an inch to the foot run is a sufficient fall for lead, that is, if the sheets be twenty feet long, and hence they will require to be laid five inches higher at one end than at the other. This inclination, or, as it is called, giving a *current*, is generally apportioned and determined on by the carpenter and plumber previously to the laying of the lead, while the former's part of the business is doing.

Flushings, as they are called, are pieces commonly of milled-lead about eight or nine inches wide, and fixed all round the extreme edges of a flat or gutter, in which lead has been used. If a wall of brick-work surround it, it is passed into the joint between the bricks and its other edge, dressed over that of the edge of the lead in the flat or gutter, and when no joint can be found to receive its upper edge, it is then fastened by wall-hooks, and its other edge dressed down as before.

Drips in Flats or Gutters consist in raising one part above another, and dressing the lead as has been described for covering the rolls. They are had recourse to when the lengths of the gutter or flat exceed that of the length of the sheet, or sometimes for convenience; they are also an expedient to avoid joining the lead by soldering it.

The pipes used by the plumber are of various sizes as well as description. All the smaller sizes are called by their caliber or bore, thus, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, $1\frac{3}{4}$, and 2-inch pipe.

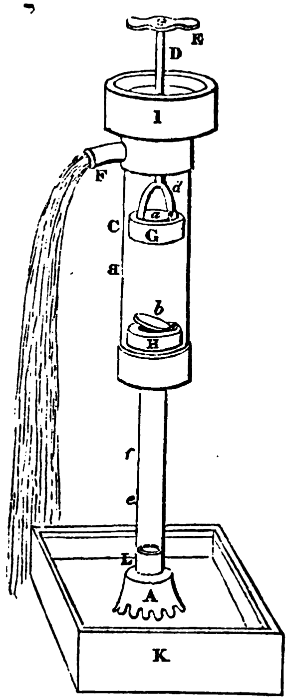
Plumber's work is commonly estimated by the pound or hundred weight; but the weight may be discovered by the measure of it, in the manner below stated. Sheet-lead used in roofing, guttering, &c. is commonly between seven and twelve pounds weight to the square foot; but the following table shews by inspection the particular weight of a square foot for each of several thicknesses.

Thickness.	Pounds to a Square Foot.	Thickness.	Pounds to a Square Foot.
10	5,899	15	8,848
11	6,489	16	9,438
$\frac{1}{6}$	6,554	$\frac{1}{6}$	9,831
12	7,078	17	10,028
$\frac{1}{8}$	7,373	18	10,618
13	7,668	19	11,207
14	8,258	$2=\frac{1}{5}$	11,797
$\frac{1}{7}$	8,427	21	12,387

Weight of Pipe.

In this table the thickness is set down in tenths and hundredths, &c. of an inch; and the annexed corresponding numbers are the weights in avoirdupoise pounds, and thousandth parts of a pound. So the weight of a square foot of $\frac{1}{10}$ or $\frac{10}{100}$ of an inch thick, is 5 pounds and 899 thousandth parts of a pound; and the weight of a square foot to $\frac{1}{9}$ of an inch thickness is 6 pounds and $\frac{554}{1000}$ of a pound. Leaden pipe of an inch bore is commonly 13 or 14 pounds to the yard in length.

The Construction of a Pump should now be adverted to, and with this useful instrument we may conclude our volume.



Hold the model *D C B L* upright in the vessel of water *K*, the water being deep enough to rise at least as high as from *A* to *L*. The valve *a* on the moveable bucket *G*, and the valve *b* on the fixed box *H*, (which box quite fills the bore of the pipe or barrel at *H*), will each lie close by its own weight upon the hole in the bucket and box, until the engine begins to work. The valves are made of brass, and lined underneath with leather, for closing the holes the more exactly: and the bucket *G* is raised and depressed alternately by the handle *E*, and rod *D d*, the bucket being supposed at *B* before the working begins.

Take hold of the handle *E*, and thereby draw up the bucket from *B* to *C*, which will make room for the air in the pump all the way below the bucket to dilate itself, by which its spring is weakened, and then its force is not equivalent to the weight or pressure of the outward air upon the water in the vessel *K*; and therefore, at the first stroke, the outward air will press up the water through the notched foot *A* into the lower pipe, about as far as *e*: this will condense the rarefied air in the pipe between *e* and *C* to the same state it was in before; and then, as its spring within the pipe is equal to the force or pressure of the outward

air, the water will rise no higher by the first stroke; and the valve *b*, which was raised a little by the dilatation of the air in the pipe, will fall and stop the hole in the box *H*; and the surface of the water will stand at *e*. Then depress the piston or bucket from *C* to *B*, and as the air in the part *B* cannot get back again through the valve *b*, it will, as the bucket descends, raise the valve *a*, and so make its way through the upper part of the barrel *d* into the open air. But, upon raising the bucket *G* a second time, the air between it and the water in the lower pipe at *a* will be again left at liberty to fill a larger space; and so, its spring being again weakened, the pressure of the outward air on the water in the vessel *K* will force more water up into the lower pipe from *e* to *f*; and when the bucket is at its greatest height *C*, the lower valve *b* will fall, and stop the hole in the box *H*, as before. At the next stroke of the bucket or piston, the water will rise through the box *H* towards *B*, and then the valve *b*, which was raised by it, will fall when the bucket *G* is at its greatest height. Upon depressing the bucket again, the water cannot be pushed back through the valve *b*, which keeps close upon the hole whilst the piston descends; and upon raising the piston again, the outward pressure of the air will force the water up through *H*, where it will raise the valve, and follow the bucket to *C*. Upon the next depression of the bucket *G*, it will go down into the water in the barrel *B*; and as the water cannot be driven back through the now closed valve *b*, it will raise the valve *a* as the bucket descends, and will be lifted up by the bucket when it is next raised. And now, the whole space below the bucket being full, the water above it cannot sink when it is next depressed: but, upon its depression, the valve *a* will rise to let the bucket go down; and when it is quite down, the valve *a* will fall by its weight, and stop the hole in the bucket. When the bucket is next raised, all the water above it will be lifted up, and begin to run off by the pipe *F*. And thus, by raising and depressing the bucket alternately, there is still more water raised by it; which, getting above the pipe *F*, into the wide top *I*, will supply the pipe, and make it run a continued stream.

So, at every time the bucket is raised, the valve *b* rises, and the valve *a* falls; and at every time the bucket is depressed, the valve *b* falls and *a* rises.

As it is the pressure of the air or atmosphere which causes the water to rise and follow the piston or bucket *G* as it is drawn up; and since a column of water thirty-three feet high is of equal weight with an equal column of the atmosphere, from the earth to the very top

of the air; therefore the perpendicular height of the piston or bucket from the surface of the water in the well must always be less than thirty-three feet, otherwise the water will never get above the bucket. But when the height is less, the pressure of the atmosphere will be greater than the weight of the water in the pump, and will therefore raise it above the bucket: and when the water has once got above the bucket, it may be lifted thereby to any height, if the rod *D* be made long enough, and a sufficient degree of strength be employed to raise it with the weight of the water above the bucket.

The force required to work a pump will be as the height to which the water is raised, and as the square of the diameter of the pump-bore, in that part where the piston works. So that if two pumps be of equal heights, and one of them be twice as wide in the bore as the other, the widest will raise four times as much water as the narrowest, and will therefore require four times as much strength to work it.

The wideness or narrowness of the pump, in any other part besides that in which the piston works, does not make the pump either more or less difficult to work, except what difference may arise from the friction of the water in the bore; which is always greater in a narrow bore than in a wide one, because of the greater velocity of the water.

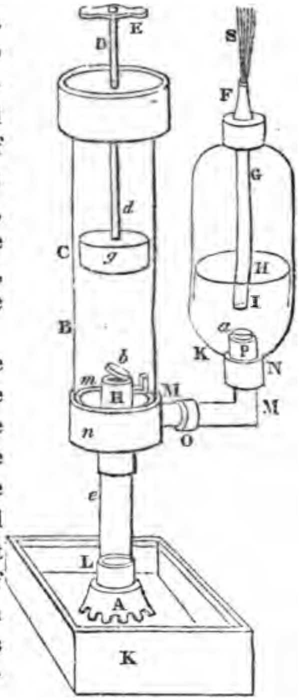
Should the disproportion between the suction-pipe and piston-barrel be very considerable, the labour of working the pump will be materially increased. Instances, however, have occurred, in which pumps have been so constructed as to raise cannon-balls by the momentum of the ascending column of water; and when hydraulic engines are constructed for the use of vessels, this mode of increasing the velocity of the water appears well adapted to prevent the pump choking or becoming foul.

The pump-rod is never raised directly by such a handle as *E* at the top, but by means of a lever, whose longer arm (at the end of which the power is applied) generally exceeds the length of the shorter arm five or six times; and, by that means it gives five or six times as much advantage to the power.

The *forcing-pump* raises water through the box *H* in the same manner as the sucking pump does, when the plunger or piston *g* is lifted up by the rod *D d*. But this plunger has no hole through it, to let the water in the barrel *B C* get above it, when it is depressed to *B*. and the valve *b* (which rose by the ascent of the water through the box *H* when the plunger *g* was drawn up) falls down and stops the hole in *H*, the moment that the plunger is raised to its greatest height. Therefore, as the water between the plunger *g* and box *H* can neither get through the plunger upon its descent, nor back again into

Force Pump.

the lower part of the pump *L e,* but has a free passage by the cavity around *H* into the pipe *M M,* which opens into the air-vessel *K K* at *P;* the water is forced through the pipe *M M* by the descent of the plunger, and driven into the air-vessel; and in running up through the pipe at *P,* it opens the valve *a;* which shuts at the moment the plunger begins to be raised, because the action of the water against the under side of the valve then ceases.



The water, being thus forced into the air-vessel *K K* by repeated strokes of the plunger, gets above the lower end of the pipe *G H I,* and then begins to condense the air in the vessel *K K.* For, as the pipe *G H* is fixed air-tight into the vessel below *F.* and the air has no way to get out of the vessel but through the mouth of the pipe at *I,* and cannot get out when the mouth *I* is covered with water, and is more and more condensed as the water rises upon the pipe, the air then begins to act forcibly by its spring against the surface of the water at *H:* and this action drives the water up through the pipe *I H G F,* from whence it spouts in a jet *S* to a great height; and is supplied by alternately raising and depressing of the plunger *g,* which constantly forces the water that rises it through valve *H,* along the pipe *M M,* into the air-vessel *K K.*

END OF VOL. I.

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In a work of this description, the advantages of a Chronological over an alphabetical arrangement are great and obvious.

In a merely alphabetical disposition, such as has been hitherto adopted in the compilation of all Biographical Works, the subjects successively presented to view are generally so opposite and so incongruous, that no reader, however patient, can long proceed in a continuous course of reading, without experiencing displeasure and fatigue; and, even if he did continue it, such reading would be so irregular and inconsequent, as to be altogether destitute of the more important benefits resulting

from systematic arrangement. In the alphabetical order of position, as has been elsewhere observed, every article stands unconnected and isolated; no part strengthens and illustrates another; the whole is, in fact, but one large index; a confused mass, a complete chaos, of unconnected and heterogeneous parts, jumbled together without system, without order, without reason, and every succeeding edition completely destroying the preceding one.

In a Chronological Arrangement, on the contrary, these objections are obviated by a variety of advantages worthy of special enumeration:—

First. The Chronological Arrangement brings into one point of view the Lives of all those who flourished at the same period of time, while the subordinate Classification gives a clear and satisfactory idea of the progress of the various Arts, Sciences, and Pursuits, in which the various Characters were blended together or opposed to each other, so as to create a sympathy and continuity of interest with regard to them.

Secondly. The Chronological Arrangement, by the juxtaposition of Contemporaneous Lives, presents a complete and connected History of the events and pursuits of the same period, and thereby becomes a continued History of the World, from the earliest period down to the present era.

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